Fig. 1.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 1.
[SECOND EDITION.]

REPORTS OF EXPERIMENTS, CHIEFLY WITH KEROSENE, UPON THE INSECTS INJURIOUSLY AFFECTING THE ORANGE TREE AND THE COTTON PLANT,

MADE UNDER THE DIRECTION OF THE ENTOMOLOGIST.

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 14, 1883.

SIR: I have the honor to submit for publication Bulletin No. 1, from this Division, prepared in accordance with the suggestions in my annual report and under your instructions. This is the first of a series of Bulletins which I hope from time to time to submit, and which will not only facilitate the work of the Division, but place before the public current matter that would either lose much of its value if kept for the annual report, or find no space in the limited pages of that volume.

Respectfully,

C. V. RILEY,
Entomologist.

HON. GEO. B. LORING,
Commissioner of Agriculture.

INTRODUCTION.

This Bulletin contains some communications and reports by agents of the Division on insects affecting orange trees and the cotton plant, as well as on some miscellaneous insects. We have not attempted to verify the results recorded in the reports, but have endeavored to identify as far as possible the specimens referred to.

The use of kerosene emulsions is just now attracting much attention, and as there is some conflict of experience as to their value, we repeat, in this connection, our views on the subject as recently discussed in the *Scientific American*.

On the Pacific coast the horticulturists have, during the last two years, been very active in their attempts to effectually destroy scale-insects; and Mr. S. F. Chapin, a member of the State Horticultural Commission, has recently published an extensive and interesting report (*vide* late numbers of the *Pacific Rural Press*), which bears evidence of careful work, and in which kerosene is condemned and various applications of lye and whale-oil soap are strongly recommended as sufficient for the object in view. Now, our own experience with scale-insects, and that of Mr. Hubbard, show that neither of these two substances bears comparison with a proper kerosene emulsion as an effectual destroyer of scale-insects and their eggs.

We have intimated in the annual report for 1881–'82 that the discrepancy on the Pacific coast and in Florida can scarcely be explained by difference in the species dealt with, but doubtless depends on the difference in the trees treated and the methods employed. The experiments recorded in this Bulletin refer chiefly to orange trees.

Mr. Chapin refers in his experiments mainly to pear trees, and occasionally to other northern fruit trees, the report being headed, in fact, "Scale-insects on Deciduous and Ornamental Trees." The orange is not a deciduous tree, and was evidently not experimented on. Other insecticides were used by him upon pear, peach, apple, almond, prune, and plum. Now, there is no doubt but that the action of kerosene proves more injurious to some plants than to others, and in sufficient quantity is hurtful to all. It should, therefore, be used with caution where its effects are not already known, and never employed pure. Even the orange receives a shock from its judicious application, though there is abundant proof of the fact that young, vigorous shoots of this

tree will withstand a thorough drenching with the pure oil. Again, much will depend upon the condition of the tree and the time of application, as Dr. LeBaron long since showed that kerosene can safely be applied to apple trees in the spring of the year (Second Illinois Report, pp. 114, 115), or during the season of rapid growth. Again, the condition of the atmosphere will have much to do with the results, and the injury by kerosene will be greater during cool, damp weather, when evaporation is at a minimum. The fatal results in California may also be due to the large quantity used and the coarse methods of application, for Mr. Chapin's report shows that in most of the experiments it was applied undiluted, in coarse spray, while the quantity is not stated.

As two years have now elapsed since Mr. Hubbard began the use of kerosene emulsions, we recently sent him a copy of Mr. Chapin's report, with the request that he give us a *résumé* of his views, and particularly requested him to examine the trees that had been first treated with kerosene. We give herewith his report:

I have never seen any serious injury from applications of even pure kerosene. In 1880 one of my neighbors treated some very young orange trees for Lecanium scale by pouring the oil upon them from an oil can. The trees were not in very bad condition at the time, and did not appear to suffer any injury at all, and at this date they are in very thrifty condition. The applications were made at evening. On September 13, 1881, I applied to twenty-five young trees in my own grove a wash consisting of 1 pint kerosene emulsified imperfectly with 1 quart fresh milk, and diluted with 5¼ quarts water. The emulsion (No. 1) was very imperfectly united, and most of the oil rose to the surface, and as the wash was applied with a brush, the first trees washed received a large amount of pure kerosene upon the trunks, branches, and in many cases upon the leaves. This application was made in the afternoon (2 p. m. to 6 p. m.) of a very hot, clear day. The trees so treated received not the slightest harm, and at this date are among the finest in the grove, and most of them have quadrupled their size within the year. About the same date (September 14) I made, as a test, an application to two young orange trees of a very unstable mixture: of kerosene, 1 pint; of milk, 2 fluid ounces; of water, 2 ounces; which, when diluted, separated and floated on top. The mixture was applied with a brush, and the oil could be seen to penetrate the leaves, so that they appeared greasy and translucent. Applied between 12 m. and 1 p. m., on a very hot, clear day. Tree A stood in the shade of an oak tree, B in the sun. September 16, 1881: B, old, devitalized leaves loosened or fallen; A, no leaves loosened or fallen. September 20, 1881: B has dropped its leaves badly; A has dropped fewer leaves. December 17, 1881: both trees apparently cleared of living scales. February 14, 1882: trees pushing out vigorously; no apparent difference in condition of A and B; no living scales can be found. To-day, November 9, 1882, these trees are in splendid condition, and have made nearly, if not quite, the maximum growth possible in the year. In these cases the effect of the kerosene has been simply to remove the scale; the rest is due, of course, to cultivation.

Another test, which I intended to be crucial as to the effect of diluted kerosene wash upon the roots of the orange, was made at the same time, September 14, 1881. In this experiment I selected a very small, two-year-old, budded orange tree, which had made no growth during the year, was starved and hide-bound, and stunted. Every orange grower knows how difficult it is to start such a tree into vigorous growth. I dished the earth around this tree and poured a gallon and a half of kerosene wash, containing 1 pint of the oil in emulsion with milk, into the cavity about the base of the tree, so that the whole of it soaked into the sand on and about the roots. The tree

had but a few yellowish leaves, and most of these dropped within a week. It, however, pushed out new leaves during the winter, and made a respectable amount or branch growth during the past summer. At this date, far from being in dying condition, it is evidently prospering as well as its gnarled and stunted trunk will allow, and I do not hesitate to say that the shock of the kerosene started it from its dormant condition. I might give other instances of applications with kerosene used unnecessarily strong or in imperfect mixtures with other liquids, in none of which have the trees been killed within the past year, but I prefer to cite only from my own notes. In the California report the concentrated solutions of lye seem to be recommended, although the effect upon the trees is evidently very severe. *E. g.*, "No. 3, concentrated lye, one and one-half pounds; water, one gallon. June 23, 1881, lye so strong as to burn bark and foliage. * * * August 2, 1881; * * * bark being restored and new foliage appearing." I should call this heroic treatment. It would never do for orange trees, because it would make them hide-bound, if it did no worse. I made four experiments with potash lye (see Preliminary Report, table 6). The strongest solution is 1 pound to 1¼ gallons, applied December 31, 1881 (Exp. 43). I find I have the following notes upon the condition of the tree: January 10, 1882, "Until within two or three days, the tree has not dropped many leaves. It is now severely defoliated. January 20, has ceased to drop leaves; defoliation complete upon the most badly infested branches; no leaves dropped on the most vigorous branches; some dropped on nearly all older branches." At this date (November, 1882) the tree is alive, but seems to be suffering from a severe check, and hardening of the bark. The result on scale was not at all satisfactory in my experiments, but I have since had reason to suspect that the concentrated lye used was not a good article. Mr. Voyle, who has tried apparently the same brand, told me that he suspected there was "no *potash* in it." What was substituted he could not say, but it might be some form of caustic soda. I have had it in mind to repeat these experiments with a brand of potash known to be good. Shall I do so? In my experiments Nos. 43, 44, and 45 (see Report, table 5) the trees were in very bad condition, coated with scale. I looked at them the other day, and they seemed to me to be in dying condition. This, however, may be partly due to scale, as the lye did not clear the tree. They have, however, been repeatedly washed, with the other trees in the same grove, during the past summer, the washes used being soap and kerosene emulsions of the strength I have recommended, *i. e.*, 66 per cent. oil in emulsions, emulsion diluted nine or ten times. That the present condition of these trees is not attributable to the kerosene is shown by the surrounding trees, many of which were in equally bad condition, but *all* of which show marked improvement.

The further experience in this Bulletin, so far as it goes, bears out that above stated, and we shall continue experiments with the sole view of establishing the facts in relation to an insecticide which we have, thus far, good reason to believe is the most valuable for scale-insects yet in our possession.

C. V. R.

MISCELLANEOUS NOTES ON ORANGE INSECTS.

By H. G. HUBBARD.

THE RUST MITE AND NOTES ON OTHER ORANGE PESTS.

CRESCENT CITY, FLA., *September* 15, 1881.

SIR: On September 1, I obtained the first specimen of a coleopterous borer in orange. I have since obtained two more from which I hope to raise imagos.* The borers were found in young trees budded three years ago. The larva had in each case begun in the dead end of the old stump above the bud. As these dead ends were only a few inches long, the borer entirely hollowed them out, and, after eating all the dead wood, descended a short distance into the living wood at the base of the budded stalk. There was always a copious exudation of gum, and in one case this had attracted an ant, which began to nest in the upper part of the gallery. Undoubtedly this borer does great harm when forced to bore into the living wood, and in many cases must cause the death of the budded part of the young tree. The obvious remedy, or rather precaution, will be to trim closely these ends of the stump, as soon as the bud has made a strong woody growth. This will be the second year after budding.

Experiments with pyrethrum extract diluted with water, and applied to leaves infested with "rust mite," have not been successful, and the mites have not been killed. Probably the extract is not strong enough. I have continued to accumulate evidence of a connection between the presence of the mites on oranges and the subsequent appearance of rust. It is always possible to determine whether leaves have or have not been infested with the mite, although they do not remain upon a leaf longer than four or five days. The upper surface shows plainly the result of their attack in a fine wrinkling of epidermis. On the fruit there is a similar effect, and, in addition, the exuviæ of the mites adhere to the surface for several weeks after the mites have gone. I am now trying to determine how long a period elapses between the disappearance of the mites and the appearance of the rust. A number of bearing trees, on which all the fruit is bright, have been examined, and in all such cases no rust mites have been found, nor any traces of their having been upon the leaves. Trees upon which *all* the fruit is rusted invariably show the effects of the mites upon

* *Elaphidion inerme* Newm.

nearly every leaf. In a large number of cases where the fruit of one side, or certain branches, is rusting, the leaves of these parts show mites or their work. I have not yet found a tree in which this connection between the mite and rust upon the fruit could not be detected.

Experiments with Neal's mixture* give upon the whole rather disappointing results. The scales are certainly killed by it in large numbers, and if thickly and thoroughly applied, about 80 per cent. of the gravid scales with their young and unhatched eggs are killed, and very nearly all the very young scales are also destroyed. But it is also certain that it injures the tree, to some extent, by coating the bark and surface of the leaves. I do not think that permanent injury is done by it. Very much the same thing can be said of the washes in common use, most of which are compounds, in varying proportions, of soap, whale-oil soap, lye, soda-ash, and sometimes sulphate of iron and sulphate of copper. These last are very injurious to the trees, and I do not think they are very effective as a remedy against the scale. I have seen oranges entirely ruined, and with the rind eaten through, by applications of blue-stone, while the effect upon the scales appeared to have been almost nothing.

On September 3 I drove over to Welaka, on the Saint John's River, about 8 miles from here. I found the scales in about the same condition as here; no apparent difference in the number of eggs hatched. Rust appears to be doing an unusual amount of damage everywhere this year. On the way back I had occasion to examine a lemon tree which I last saw in May, 1880, and which at that time was badly infested with the "bran-scale" (*M. citricola*). It is now almost entirely free from scales, and growing vigorously, although nothing had been done to it, and the tree had not even been fertilized. I have several times seen evidence that this scale (*M. citricola*) is more subject to attacks of enemies than the "long scale" (*M. gloverii*). This may be due to the fact that it is much thinner and not so tightly cemented to the bark. At any rate it is not nearly so much feared by orange-growers, and the opinion is often expressed that it will disappear from any tree in a few years of itself if left undisturbed.

On September 4 a gentleman brought me a specimen of *Euphoria melancholica* which he had taken with others in the act of eating holes in the bark of an orange tree. He says that one of his trees has been badly attacked by them, and he has killed a number on several occasions, finding them at work on the tree. They have eaten a succession of holes through the bark, each hole about the diameter of his little finger. The bark splits between the holes where several are cut near each other. There was a small black ant feeding upon the exuding gum at the same time. It seems to me possible that the ants were the originators of the mischief and the beetles were only feeding upon the

*The reader is referred to the Annual Report of the Department for 1881–'82 for a description of this mixture.

sap. He, however, thinks not. I have already reported an ant as eating holes in leaves and bark, but this supposed habit of the cetonian beetle is new to me.

Neal's mixture appears to be effective, applied with a scrubbing-brush to the trunks of trees infested with "bran-scale" (*M. citricola*). Of two trees examined September 3, one had been scrubbed several weeks before, and hardly any young scales could be found. The other tree adjoining it had not been scrubbed; the main trunk is sprinkled over with young scales, still white in color, and with very thin shells. They appear on the bark as a whitish powder or dust. This scale is apt to be found confined to the main trunk of large trees. It spreads upward from the ground, and quite slowly, *i. e.*, taking several years to reach the branches. Many old trees have the upper portion of their trunks quite free from the scale, while near the ground the bark is thickly coated with them.

September 5.—I visited some young groves 4 miles southwest of Crescent City. The trees were badly infested with rust mite, which I found on lemon and citron, but not on limes (the limes were killed to the roots last winter). There were two bearing orange trees close to a house, but not more than the average distance (25 feet) from infested trees, which were entirely free from rust mite, on leaves and fruit, the latter not rusted in the slightest degree, and the foliage, by its glossy green, presenting a most remarkable contrast with that of the trees in the grove just over the fence.

September 6.—Examined the tree upon which I found (August 27) the little black ant eating holes in leaves. I found the ants still at work, but, as the colony is a small one, no very great damage has been done. The tender shoot most attacked has ceased to grow. It has a few Aphis upon it, and these are attended by the ant. Some of the leaves eaten are so placed that no honey-dew could have fallen upon them from these Aphis, which are, moreover, but few in number and all young. There were, August 27, a very few scales of the Lecanium on the tree; these are all dead. The ants are still gathered about the same holes they had begun when last examined, although the leaves are no longer tender and are now quite dry and partially dead (entirely dead where much eaten by the ants). The ants eat only from the under side, and devour all the parenchyma, sometimes leaving the upper epidermis and sometimes perforating the leaves.

The little coral-red maggots, feeding upon "rust-mites," and described in my last letter, prove to be Cecidomyid flies. They are exceedingly difficult to raise, and most of them dry up in confinement. Four of them, however, made little oval cocoons of white silk, after a week's confinement during which they fed but little and did not appear to grow. Three of the flies appeared in nine to ten days after making their cocoons.

A young sour seedling orange plant, entirely covered with "long scale" (*M. gloverii*), and thoroughly covered with Neal's preparation on

August 31, gives to-day, September 7, the following result: *All* the very young scales killed; nearly all scales one-third grown killed; scales half grown, 34 killed, 11 alive; full-grown and gravid ♀ scales: mother insect and all eggs dead and dried up, 22; mother insect apparently alive, but larvæ and portion of the eggs at end of scale dried up, 15; mother insect and all the eggs uninjured, 10. Of the ♂ scales, the greater part were empty at the time of the application; there were, however, some with living ♂ pupæ; of these most appear to be killed; 6 living pupæ were found. The plant, which was most thoroughly treated, has lost all the older, devitalized leaves (not a bad thing), and shows some signs of injury from the application, but may be benefited in the end. It has not started any young growth. When treatedi t was dying of scale attacks.

September 8.—Visited Harp's grove. Many trees (bearing, and eleven or twelve years old) infested with *M. gloverii* or *M. citricola*, or both. A tree near the house was dying from scale insect; over half of it had been cut away in former years, being entirely covered with long scale. It was washed in May last (1881) with Benham's mixture (ingredients supposed to be soft soap, whale-oil soap, potash, lye, and probably sulph. of iron, &c.), and is now entirely free from scale and bearing for the first time in several years. About 8 gallons of the wash applied with an ordinary syringe with rose sprinkler. The tree is a seedling sweet orange, and was in bloom when the application was made. The tree was very thoroughly treated, and was intended to be a test by the inventor of the wash. Several other trees, mostly infested with *M. cit ricola*, were shown me, washed during the early part of August; same mixture, sprinkled several gallons to each tree. On these the effect has not been so complete, and the scales are spreading again. The mixture used upon some trees has turned black and spoiled, and has had no effect whatever.

Harp's grove is and has been noted for its bright oranges; the fruit of many trees is entirely free from rust, and on these a most careful search failed to reveal any "rust-mites" on fruit or leaves. A few trees in one part of the grove show rusty fruit and mites on leaves and fruit. An occasional orange is found, the rind of which has been eaten and perforated by a lepidopterous larva. This in every case worked under a leaf which happened to be closely applied to the surface of the fruit, and had been fastened down by a web. The larva does not appear to differ from that of one of the common leaf folders, and is probably a Tortricid. The fruit perforated is invariably lost and drops from the tree, owing to the attacks of a fly maggot, which enters and feeds upon the juice, rotting the fruit. The Nitidulid beetle, *Carpophilus ferrugineus* Murray, also attacks such injured oranges, and its larva also occurs in the rotting fruit.

Mr. Harp's cotton is being ragged by Aletia. The caterpillars are one-half to two-thirds grown, with younger and older worms mixed. I saw

no webs, but did not hunt for them. Harp first noticed the leaves eaten about a month ago (early in August), but saw no worms at that time. He has also a field of sweet potatoes, the leaves of which are now about half eaten by a dark-colored, striped worm (apparently a Prodenia). A neighbor's potatoes were eaten out (the leaves) three or four weeks ago, at which time Harp had only a few worms. They "stopped for a time," and have now "begun again" in much greater numbers. The ground under the vines, at noon, was covered with worms, many of them full-grown. Harp will not poison with Paris green, because he expects the worms to leave as soon as they have eaten all the leaves, and the vines will make new leaves which he intends to feed as fodder to stock. If he poisons and saves the balance of these leaves he cannot feed them to stock.

September 9.—Discovered another Cecidomyid larva preying upon "rust mite," in company with that before mentioned. This larva is very similar to the former, but is yellow, with white tubercles. It is more slender in form, more tuberculate, the tubercles bearing longer hairs. The anal fork is longer and stouter and jointed, and the antenna-like projection from the head is longer and more slender.

September 10.—An orange-colored Reduvius invariably makes its appearance upon trees which have been infested with *Lecanium hesperidum* (this coccid is out of season and not abundant). Such trees are now blackened with a smut fungus, which appears to follow the Lecanium, and are usually foul with spiders and other predaceous insects. There are always some individuals of the Lecanium to be found, and these seem to be much relished by the larvæ of Hemerobius, Chrysopa, &c.

There are many locusts that eat orange leaves. At this season the majority of them are immature, mostly pupæ. To-day (September 10) I detected the weevil *Notolomus basalis* eating the leaves of orange. It is often found on the trees and usually in the shelter of a curled leaf occupied by a spider's egg-nest or the deserted gallery of a leaf folder. The Notolomus gnaws the upper surface of a leaf in which it has found a retreat, but does no appreciable harm as far as I have seen. When the scrub palmetto is in bloom this weevil is found in great numbers on the blossom. I do not think it has any especial connection with the orange tree beyond fretting an occasional leaf.

September 12.—Made applications of kerosene and milk to trees infested with long scale. I have no pump as yet, and am obliged to make experiments on a very small scale. The kerosene applied was stirred slowly with milk and thoroughly combined before diluting with water. The proportions were one pint kerosene to one quart fresh milk and seven quarts water.

Very respectfully,

H. G. HUBBARD.

Prof. C. V. RILEY,
Entomologist.

THE RED BUG (Dysdercus suturellus) AS AN ENEMY OF THE ORANGE.

CRESCENT CITY, FLA., *January* 17, 1881.

SIR: A few days ago I learned that the "red bug" of cotton (*Dysdercus suturellus* H. Sch.) was puncturing oranges in Squire Harp's grove. To-day I visited Harp's grove, and found not a single orange upon the trees. The greater part of the crop has been gathered, and the remainder destroyed by the bugs. Rotten and rotting oranges lay scattered about under the trees, and upon all those which were not entirely decayed the red bugs clustered thickly. Bugs also gathered upon fragments of dry orange-peel upon the ground. Was shown a pile of fruit in packing-house, now entirely rotten, and which consisted of 3,000 oranges (counted). This fruit was destroyed in part while in the packing-house, the bugs having followed it into the house, which stands in one corner of the grove. Cotton has been planted for several successive years in the grove and fields adjoining. This year cotton is planted in one portion of the older grove, and in several fields nearly surrounding it. The cotton has not been kept picked, and stalks as well as the ground are white with the waste lint and seed. To this the bugs are now returning, although for a time they are said to have nearly deserted the cotton for the oranges. Last year I remember to have seen the red bug in moderate numbers in this and other fields in the vicinity, but never saw any on the oranges. The bug has never before been known to attract notice of cotton or orange growers in this place. Last year I found them very abundant at Hawthorne and elsewhere in Alachua County, but not extending farther north than Gainesville. Dr. McMeekin, of Hawthorne, and others about there, were seriously damaged as to cotton. I think I heard a statement by him, or some one of his neighbors, that the bug attacked oranges, but do not remember that any serious complaint was made. My notes (spring of 1879) will show what was said at that time. Here at Crescent City there has been some cotton (all "sea-island") raised for ten or twelve years, but until last year the acreage was very small. Lately a cotton-gin has been established here, and a much larger acreage of cotton has been planted in consequence by Harp and his immediate neighbors. Most of the cotton planted has been in Harp's immediate vicinity, although a number of other settlers have utilized the ground in *young* groves by planting cotton between the rows of orange trees. This practice, after one or two years' experience, is being abandoned by most of the orange-growers, but it is likely to be continued by a few natives of Georgia, who have always been accustomed to raise some cotton.

In puncturing the orange the bugs insert their fine sucking beak often its entire length, and while it seems to me that the oil of the rind is their principal food, yet in some instances they penetrate through

the rind and into the pulp of the orange. Many were seen sucking dried orange peel which had been cut from the fruit and thrown upon the sand. The bugs at Harp's were in all stages of growth, and of all sizes. Many adults in copulation. As the eggs are not deposited in masses, but dropped singly in the sand, none were seen. They are evidently now breeding with great rapidity, as the weather for the past ten days has been very warm. Oranges attacked by the red bugs show no traces of punctures externally, but drop from the trees and soon rot. The side which rests upon the ground usually softens first, but this is not invariably the case. Harp has lost a large part of his crop, and says the whole profit made on his cotton has been wiped out by the loss on his oranges. A single tree near the house, and at some distance from the cotton, still bears a few oranges upon the upper branches, 20 feet from the ground. Every orange now upon this tree has from six to twelve red bugs (adult) clustering upon it and sucking. If not picked they will drop in two or three days, and in any event they will rot.

January 18.—Heard to-day that the red bugs had attacked Newsom's grove, and immediately visited it. I found a large force of men stripping the trees of fruit and packing them for shipment. Red bugs, although not as numerous as at Harp's, were seen upon nearly every tree which bore fruit; even upon the topmost branches they were seen wandering over the fruit and puncturing it. Many were also seen flying from tree to tree. On the ground under the trees, which was littered with freshly-fallen fruit, comparatively few bugs were seen. They seem to prefer the fruit on the tree, probably because of the shade, as the bugs do not like the direct rays of the sun. As there was an abundance of fresh fruit, the bugs did not attack scraps of orange peel upon the ground, as at Harp's. I saw in one instance a cluster of bugs sucking the pulp of a freshly-torn fragment of orange. In this case they did not insert the boring tube, nor unsheath it, but sucked the surface of the moist pulp with the tip of the proboscis, like flies. Nearly all the bugs were fully adult and winged. I saw but one or two young, with wing-pads partly developed. It is more than probable these bugs came by flight from the cotton fields at Harp's and his vicinity. Harp's is the nearest cotton. It is distant 3 miles southwest. Dr. Newsom first noticed a few red bugs in his grove about two weeks ago, but gave them no particular attention, as he was entirely unaware of their power to injure fruit. Dr. N. has raised no cotton for years. With one exception none has ever been raised by any of his neighbors other than Harp, and a few others still farther to the southwest. This exception was a single isolated field of cotton raised last year at a distance of a quarter of a mile to the south. One man in this vicinity fertilized his young grove with cotton seed two years ago, but no one has since done so. Harp and others that raise cotton in that neighborhood, of course, fertilize with the seed, where cotton is raised in the grove. Dr. N. had been absent for a week, and upon his return, day before yesterday, found

the red bugs in force, and fruit dropping and rotting. I add a record of maximum and minimum temperature for this month to date, with direction of wind at noon, and character of sky, &c. The first week in January was cold, with frost the first three nights, and northerly winds in the morning. Remainder of the month warm and dry, with southerly winds and clear sky. Temperature at noon for past two weeks has been about 73°. There are no bearing groves in a direct line between Newsom and Harp. A large bearing grove, Gautier's, joins Newsom on the north, with some scrub and heavy timber between the two. The red bugs have not yet migrated to Gautier's grove.

I think this a newly-acquired habit of the Dysdercus, and one which is likely to prove dangerous to orange-growers. My reasons are:

First. The red bug is a very prolific breeder, having no special breeding season, but copulating and laying its eggs at all times when the weather is warm. It increases as rapidly as any insect I know of, and infests cotton in prodigious numbers.

Second. In this district there are no permanent plantations of cotton. The acreage varies greatly from year to year, at one time stimulating the bugs to very rapid increase, and at another leaving vast numbers of them without sufficient food. This might tend to force a change of food, and the migratory habit.

Third. The red bug is one of those showy insects which are probably protected from enemies by the possession of an acrid flavor (they do not seem to have any odor). I cannot yet observe any birds or other enemies preying upon them. Chickens, &c., do not eat them.

Orange-growers in this vicinity are somewhat alarmed, and will, I think, give up raising cotton, which, moreover, has never been profitable here. I have recommended to Dr. Newsom and others to rake together the fallen and rotting fruit into piles, as soon as the fruit on the trees has been gathered. These will attract the bugs, and they may be destroyed either with pyrethrum or, better, perhaps, with diluted kerosene, which will sink into the sand and destroy the eggs also. After the fruit has rotted, and no longer serves to attract the bugs, little piles of cotton seed may be used as traps in the same way. It ought to be very easy with some concerted action to stamp out the pest in this its beginning. I have also searched in the bushes and weedy fence corners about Newsom's place to see whether the bugs could not be detected upon some oily seeds, such as cockle-bur, urena, &c. But, apparently, the oranges have attracted them all, and I cannot find a single wanderer outside the grove.

Very respectfully,

H. G. HUBBARD.

Prof. C. V. RILEY,
Entomologist.

CRESCENT CITY, FLA., *November* 28, 1882.

SIR: Since I last wrote I have been occupied in making drawings, and have finished the rust mite and its two enemies (larvæ), Syrphus fly of orange Aphis—larva, imago, and puparium; also, sketches and details of several other orange insects. I confine myself at present mainly to such drawings as need to be made from fresh or living specimens. Some biological work is also in progress, and I have tried very hard to breed the flies of the rust mite enemy, but so far I have failed to get specimens fit for drawing. Experiments made in September with kerosene washes on purple scale (*M. citricola*) show that the eggs are much more difficult to kill than I had supposed. They have not been killed by 66 per cent. kerosene and soap emulsions diluted 1 to 9. This scale has been somewhat neglected in my last year's work, and I now find it important to get separate results for this scale. We have been having cold weather, with several very slight frosts, and I find the action of the kerosene very severe upon the foliage when frost or cold weather occurs soon after an application. In spring or summer the amount of defoliation depends entirely upon the condition of the trees, but at this season atmospheric conditions appear to have a great influence. When the air is charged with moisture, and the nights are cold, with frost or heavy dews, the oil does not evaporate as rapidly as in warm or dry weather, and consequently the effect of an application upon the foliage is much more severe. I cannot detect any injurious effect on the bark. When defoliated the trees push out new growth almost immediately, and it seems to be the general opinion that this is not desirable when there is danger of frost. On the whole I am inclined to think it a risk to wash trees in winter or late in the fall. If, however, the trees have been neglected, and are badly infested with scale, it is perhaps preferable to run this risk rather than to allow the scales to complete their winter brood. I expect to learn much on these points the coming winter, as I think we will have one or two frosts before or soon after Christmas.

I have carefully gone over Dr. Neal's report, and have a few comments to add to my former communication.

Dr. Neal says "the greater the percentage of rosin in the soap the better the emulsion I found it made." This may be true of the *emulsion*, but when diluted, the rosin, or a large part of it, separates from the liquid and forms a waxy scum on the surface, which clogs the pump and nozzle, and is troublesome unless removed. This scum is insoluble, and, if heated, some free oil separates from it. In murvite I think the balsam separates in the same way from the diluted wash. Whale-oil soap, notwithstanding the impurities it contains, gives no such scum.

The strongest emulsion used by Dr. Neal contains 50 per cent. of oil, and the strongest wash a dilution of 1 to 9. My experiments with milk emulsions of this strength did not in the end prove satisfactory, and I long ago decided to increase the amount of oil in the emulsion. I now use 66 per cent. emulsions diluted 1 to 9, and these, although sufficiently

strong for long scale, are not sufficiently penetrating to kill the eggs of purple scale (*M. citricola*). I think that by next spring Dr. Neal will have considerably modified his conclusions, and will agree with me in recommending a higher grade and more penetrating emulsions. In regard to the *removal* of the scales from the tree by a second application one week after the first, I cannot but think that he is mistaken.

In regard to cost of the materials used in Dr. Neal's washes, his estimates are somewhat higher than mine, and I think he pays 5 cents per box more for milk (condensed), and probably a somewhat higher price per pound for whale-oil soap than we do here.

The following are my estimates for a standard wash of whale-oil soap and kerosene, emulsion 66 per cent. oil, diluted 1 to 9 (1 gallon emulsion = 10 gallons wash):

Whale-oil soap, ¼ pound, at 10 cents retail price, 2.5 cents; water, 1 gallon, nothing; kerosene, 2 gallons at 20 cents, 40 cents; total, 66 per cent. emulsion = 3 gallons, 42.5 cents; one gallon costs 14.166 cents.

NOTE.—There is a slight loss by water-shrinkage or otherwise, so that when small quantities are made it is sufficiently exact to put the cost of the emulsion at 15 cents per gallon.

One gallon emulsion = 10 gallons wash: cost, 1½ cents; without allowance for loss, 1.416 cents.

At wholesale rates, 18 cents for kerosene and 8 cents for whale-oil soap, the cost of the emulsion would be about 2 cents per gallon less; *i. e.*, 12⅝ cents.

With aquapult pump and cyclone nozzle, 4 gallons of wash is sufficient for 30 trees of small size, such as are usually furnished at the nurseries for transplanting; cost per tree, about two-tenths cents (exactly .18).

Trees which have been transplanted and have made two years' average growth in the grove (3 or 4 years from the bud) require one gallon of wash per tree: cost about 1½ cents (exactly 1.416 cents).

Bearing trees of full size will require from 5 to 10 gallons of wash: cost, 7 to 14 cents per tree (average about 10 cents per tree).

Very respectfully,

H. G. HUBBARD.

Prof. C. V. RILEY,
Entomologist.

EXPERIMENTS UPON SCALE-INSECTS AFFECTING THE ORANGE.

BY JOS. VOYLE.

GAINESVILLE, FLA., *October* 27, 1882.

SIR: I herewith submit to you my report of experiments on scale-insects with solutions of murvite, made as nearly as practicable in accordance with your instructions.

Respectfully,

JOSEPH VOYLE.

Prof. C. V. RILEY,
Entomologist.

In carrying on this work difficulties of various unexpected kinds presented themselves. The details of the various steps, successful or otherwise, taken in trying to overcome these, although consuming much time, I omit, being tedious and of little value in the presence of final success.

Every good result obtained has been carefully verified and practically tested in the field.

All items of importance noticed were recorded, even when not directly within the scope of scale insects.

The experiments have been confined to small trees for exact experiments, but for general results have been extended to trees of all sizes and conditions.

The first day's work under your directions showed the necessity of some better means of applying solutions. After a few days' delay, to make better arrangements for the purpose, tree after tree was sprayed, but the microscopic examination showed so small a percentage of eggs that they were remanded to the general list, and attention given to general results on badly infested trees until large percentages of eggs should again be found.

Every spraying device was given a practical trial in the field, so that by actual use its advantages or disadvantages might be fully proved. This also brought a large number of infested trees under experimental observation.

The principal damage done here is by *Mytilaspis gloverii*. *M. citricola* is usually present, but in a very small proportion. In the spring

and early summer, *Lecanium hesperidum* did much damage, but after the rainy season I rarely found it. *Parlatoria pergandii* was quite unknown to me, and I find very few persons who do know it, although their trees may be badly infested by it. I rarely find it on small twigs or on leaves, but large limbs and the trunks of trees are often incrusted by it.

Ceroplastes floridensis has done no damage here, although abundant on the gallberry bushes close by orange trees.

For exact experiments it was soon found that the best means in use for the application of solutions were very imperfect and wasteful.

Where only a portion of a tree is infested, it is unnecessary to apply a strong solution to any but that part. A brush dipped in the solution was the only thorough way of doing this without great waste.

The force-pump or aquajet sent had one of the finest spray nozzles found on any pump, but it is too wasteful for this purpose; it quickly overloads the leaves with solution; under this weight they bend down and thus prevent the spray from reaching many leaves and twigs behind them. The spray produced is not fine enough.

The eddy nozzles sent make a spray of the desired lightness, but do not throw it to a sufficient distance. They were rendered available by the following methods:

SYSTEM 1.—An eddy nozzle was attached to a long piece of small rubber tubing, and both to the end of a rod of sufficient length to hold the nozzle at any required height or position. Connecting the tube with the pump, the desired spray was entirely at my disposal.

To test its capacity and fitness for actual use, several hundred trees were sprayed, and various changes made to suit different circumstances.

The best and most economical result was obtained by dividing the labor.

SYSTEM 2.—One person takes charge of the pump and solution, another takes the rod and directs the spray. This allows the person with the rod to walk around the tree, and give his entire attention to the proper application of the spray.

For a small number of small trees a simple means was devised.

SYSTEM 3.—To a common rubber-bulb syringe a long conducting tube is attached, and to this a cyclone nozzle with a very fine aperture; then the nozzle to a short rod. To use this arrangement a small tin pail holding two or three quarts is used. The feeding tube or tail of the syringe is put into the pail and the tube tied to the bail of the pail, so that the end will be at the bottom.

The pail half filled with solution is carried on the right arm, the bulb is grasped and worked by the right hand, and the left hand carries the rod and directs the spray.

Experience with system 2 showed the necessity of some improvement. The size of the bucket is limited by the step of the aquajet. A large vessel tried proved awkward to handle. At a distance from water

the time required to bring supplies is nearly as much as to make the application. Another hand was an increase of final cost. A horse and cart require time and attention, and the horse is idle eight-tenths of the time.

SYSTEM 4.—I obtained one of the Dudley garden engines, which meets to a great extent the requirements of a majority of cases.

The reservoir contains seven and a half gallons, the pump is firmly fixed to the reservoir, which in use stands on the ground; for moving it is lifted by a lever and supported on a wheel truck, the tubing and nozzles attached as before. This implement is a very great convenience.

Although two men can do more working together than separately with this system, two are not as necessary as with the aquajet. The stability of the pump without holding, gives freedom of motion for change of position. The large quantity held in the reservoir saves time, and the truck makes moving easy, so that one man can easily and conveniently work unassisted. The wheels of the engine truck are too small for plowed grounds.

SYSTEM 5.—Placing the engine in a cart, with a further supply of solution in a barrel, driving up close to the tree, then standing in the cart, the pump can be worked and the spray directed to the exterior of the tree, driving around as required to reach all sides, is the simplest and most satisfactory method of spraying orange trees on a large scale with appliances now in market, and suggests—

SYSTEM 6.—For large groves of large trees place a kerosene barrel, with a good force-pump firmly attached to one head, in a cart. A light derrick fixed to the cart, carrying a light, strong rod twenty or more feet in length, supports nozzles at certain distances, to form a continuous sheet of spray of sufficient volume that the tree will be thoroughly sprayed on its exterior by driving around near it whilst the pump is being worked.

The interior of the tree is sprayed at another time by a cluster of cyclone nozzles or a conical cyclone nozzle.

A cart-tank might be preferred, but the system suggested enables the cart to be used for other purposes, and the pump and reservoir to be carefully housed.

The particular make and sizes of implements used are only typical; any similar arrangement used in the same way should produce like results.

The method of proceeding has been to note the extent of apparent damage done by the insect, condition of uninfested portion of the tree, if any, the condition of surrounding trees, if cultivated, if fertilized, character of soil, position on high or low land. Examining the scales with a lens, noting the variety, if parasitized, if larvæ are running about, then turning over the scales to see if eggs are present. Taking a fair sample for home examination, then applying the solution of a known strength.

The samples taken home are examined under a microscope, the percentages of scales showing work of parasites, females with eggs, young females, males, and dead from unknown causes, ascertained by actual count. Two days after, another examination is made, the appearance of the tree and scales noted, samples taken, and percentages of living larvæ and eggs noted, as before; these visits and examinations are repeated at intervals. A standard quantity of improved murvite was used containing 50 per cent. of kerosene.

The commencement of exact experiments under your directions became a continuation of work I had been engaged in during the previous three months, which I mention for the reason that the rainy season was over when I received the commission, and very different results were obtained during the hot, dry weather following.

During the wet season, when several heavy showers fell every day, and the trees were continually damp, a strong solution was repeatedly applied to scales one day, and when examined on the next, nearly all would be gone, and within a week, on exposed parts, no scales could be found.

When the dry season came there was a great difference, the cause of which was not immediately discovered. It was found that evaporation was so rapid that a solution applied to scales dried in less than half an hour. As without moisture murvite cannot act, various means for preventing this drying were tried; success was obtained by using a large percentage of free soap. One-half pound of laundry soap to one gallon of solution was found to answer; the scales remaining moist and loose, even when exposed to the direct rays of the sun.

In dry weather, following an application of murvite with water, within half an hour, produces a decidedly good effect. The scales of Mytilaspis turn bluish white and leave the tree much sooner than without the water.

By using a strong solution, one part murvite to ten parts water, and as soon as the scales are loose, throwing a large, solid stream of water from a good force-pump directly on the scales, if force enough be used all the scales of Mytilaspis, Lecanium, and Ceroplastes can be washed from the branches strong enough to resist the stream.

The scales are loosened to some extent by water only. To test to what extent the loosening by solutions might be attributed to water, the scales (Mytilaspis) on a tree were sprayed with water; after a few minutes they were slightly loose. A solid stream of water from the aquajet was then played upon the scales. With the greatest force obtainable, and the stream applied to the best advantage, not one scale was washed off. The same stream used in the same way had been often used after spraying with murvite, and the scales of the same variety nearly all washed off by it.

With Parlatoria it is advisable to always wash them off. This can the more readily be done, as, from my observation, they prefer the bark

of older branches and the trunk of the tree. They do not yield as readily as the other varieties on account of their matting together; a little scratching with the end of a piece of palmetto root, a handful of moss, or any similar thing, will make it easy to wash them off, even with a spray-nozzle.

I had ten feet of conducting hose replace the usual three feet on the engine, for the purpose of taking a solid stream up to wash off limbs thickly encrusted. This should form a portion of every equipment for this work.

No positive knowledge of the value of any application to scale-insects can be obtained without the use of a microscope. This instrument enables the observer to quickly ascertain the effect produced. Experience has shown that too much dependence may be placed on the microscope, and false results obtained; as, for instance, samples taken from different parts of a tree will often show a very different result in percentages. If samples be not taken for each examination from the same places the result may be misleading. Again, the scales are not alike in adhesiveness; some loosen more readily than others after the application of an effective solution, and many of these will be blown or washed off; percentages of the remainder will not fairly show the effects; whilst if the weather be calm and no rain falls, the results may be considered fair and reliable.

By reference to numbers 2, 3, 4, and 5 it will be seen that the immediate results are well indicated by the microscope; whilst from 8 to 17, inclusive, the results appear to be very irregular, showing no proportionate result to strength of solution used. This arises in great part from scales blown off 8 to 17 by a very strong wind, the application being made immediately after a storm. The scales had been loosened by the storm in different degrees, according to exposure, and the immediate results were greater as the exposure to the storm, and afterwards to the wind, was greater. The storm spoken of lasted for thirty hours, the wind blowing a gale, the rain falling in torrents. The wind continued to blow very hard for one day after the rain ceased.

Many of the worst infested trees, most exposed to the storm, showed, after its cessation, clean bark on the storm side, the scales being blown or washed off, and on the side away from the storm they were much more loose than usual. After a few days they became much more adherent than usual.

Solutions of murvite were applied to these exposed trees the day after the storm, and in two days the scales thus treated were nearly all gone.

Repeated experiments with solutions of various strengths prove that several parasites are unhurt by solutions which destroy the scale-insects; and it is generally the case that in the examination with the microscope, after the application of murvite solutions, large numbers of parasites are present and very active. In specimens 21 to 28 there may be cause to

suppose that parasites had accumulated from the surrounding trees where the scale-insects had been destroyed, the parasites having lived. Parasites are not always present on infested trees. It must be borne in mind that the results given are from only one application of murvite.

In every instance it is probable that some scales escaped the spray. Where no living insects or eggs were found, it is probable that the work was finished by the parasites.

The results shown in the special experiments were verified by the general results in the field. Over two thousand trees were the subjects of experiments, and these were of all sizes, but principally from four to ten years old. Some trees, as shown by the table, would be entirely cleared of insects, whilst others, apparently alike in every way, would have a quantity of living eggs, and sometimes, but rarely, living larvæ.

The results to the tree itself are important. Those in Nos. 1 and 2 have been repeatedly verified; the quick destruction of the insects being followed by the quick recovery of the tree. In every instance where there was life below the infested portion, the dying of the branches has been arrested at the moribund wood. From the limbs that were thickly encrusted with scales, defoliated, the twigs already dead, in a few days after spraying with murvite young shoots pushed out through the loosely adhering scales and grew rapidly.

Many trees have quite regained their former size, after losing three-fourths of their branches early in the spring by scale-insect, and this recovery has been without manuring.

In some cases the slow recovery of a tree is caused by the rust mite, pointed out to me by Mr. Hubbard during his visit; the surface of leaves in such cases being rendered almost useless to the tree, it must make new foliage. In some cases what are known here as white ants are at the roots and retard recovery.

In all cases where everything else is favorable to growth except the insect, the tree makes unusually rapid growth after the application of murvite in sufficient strength to destroy the insect. Different strengths of solution give different immediate results. The record of results shown by the microscope in Nos. 8 to 17 is of the actual count made from the scales remaining on the trees; a large number had been blown off.

The examination on October 25 shows very remarkable final results, and suggests that weak solutions of murvite at short intervals may be adopted with success. In all cases further applications of a moderately strong solution should follow the first. It must be noted that these experiments were made with unusual care, every possible means being used to reach every part of the tree and thoroughly wet it. I find it very difficult to train laborers to do this without much unnecessary waste.

The ravages of the rust mite on the leaves and fruit of the orange are next in importance to the scale-insect. Being almost invisible to the

naked eye it escapes notice, and the leaves of the tree being damaged the tree stands still. In every case of fruit splitting that I have examined the rust mite had damaged the leaves, and sometimes, but not always, *P. pergandii* was on the trunk and large limbs.

A solution of one part murvite to five hundred parts water is instant death to rust mites, also to migratory scale-insects.

A number of large trees that were making no growth, and were not infested by scale insects, on examination were found to be covered with rust mites. These trees were sprayed with a weak solution of murvite September 14; examined October 26, they were found covered with an abundance of new shoots.

Many bronzed oranges on the trees, sprayed with strong solutions of murvite whilst the oranges were growing, turned bright.*

Statements concerning the influence of soil, cultivation, manuring, and position are worthy of notice. The majority of the trees treated have been highly manured, many of them carefully cultivated. Some were on high land, some on low land, some on wet, some on dry, some exposed with no protection of buildings or trees, some close to houses and protected on every side, some on land naturally rich, others on land naturally poor, some groves well drained, some not. I find no difference in the work of the insects on trees thus variously located. In rich hammock land trees are killed down by them as badly as on high or low pine land.

A fungoid growth, of which I send a drawing, was found on Parlatoria and Mytilaspis towards the end of the rainy season, and for some time after during the dry weather of September. Whenever found with capsules developed on Mytilaspis the contents of the scales were dead. On Parlatoria its effect was not ascertained, as the insects in every stage of life, with a large number of dead, existed under the greatest growth of fungus. Disappeared about the end of September.

A red fungus was also noticed, but it disappeared before any decided results could be attributed to it. Scales of some sort were always associated with it.

Several wild orange trees, sour and bitter-sweet, quite as badly scaled as any sweet trees, were sprayed, but on examination so small a number of eggs were present that they were left for general results.

Ceroplastes is very easily destroyed. After an application of 1 part murvite to 40 parts water, in two days I could find but few on the tree, and none living.

Murvite does not dissolve readily in cold water. If dissolved in a small quantity of warm water it may afterwards be diluted with cold water to the extent desired.

The decisive results obtained by these experiments are:

The practicability of immediately arresting the progress of injury to the orange tree by certain varieties of scale insects.

* We have serious doubts as to the accuracy of this conclusion.—C. V. R.

The retention to the tree of all infested wood that is living at the time of treatment, and restoring the tree to a healthy condition.

The destruction of the insects without injury to many of their parasites.

Preventing the bronzing of the fruit and damage to the leaves by the rust mite.

Methods of applying solutions in the most thorough manner, with the greatest possible dispatch and economy of material.

Adapting these means to the varied wants of parties engaged in orange culture.

NOTES OF EXPERIMENTS.

TREE NO. 1.

August 15.—Cut down to three feet from the ground and budded; good shoots from buds. Bark covered with thick scale, variety known as hominy scale, color clay-ground speckled with white; nowhere is the bark visible. This scale has resisted everything applied to it. Applied one part of murvite to five parts water. Ten minutes after application the scale was found to be loose; it was wiped off with a wisp of dry grass, with but little force. The bark was found to be green but ridged. After cleaning the tree had a healthy appearance; weather hot. This and surrounding trees had been highly manured; soil good pine land, a little wet, ditched.

Mr. Hubbard classified the scale as *Parlatoria pergandii*. It was covered by a fungoid growth that matted the whole together. The capsules of the fungus I found were the white spots, the general color being gray.

August 23.—Tree thriving.

September 8.—Tree has made heavy, healthy growth.

October 25.—Tree still growing.

TREES NOS. 2–5.

August 16.—Tree No. 2 is in a well cultivated, highly manured, young grove of very thrifty trees, on fine land, thoroughly drained; its trunk is 4 inches in diameter at the ground; diameter of head 6 feet; height 8 feet; has lost about one-half of its branches by *M. gloverii*. Took samples inside and sprayed with a solution of one part murvite to five parts water. Returned one hour afterward and threw a stream of water on the scales from a good force-pump. The scale was readily washed off the young, smooth bark, and much was washed from the rough, older bark, but not all. A greater force would clean off all the scales. The scales washed turned bluish white in color.

Three other trees near by, similarly infested, were sprayed: No. 3 with solution 1 to 10, No. 4 with 1 to 20, No. 5 with 1 to 30. No water was

used on these trees. Weather hot and dry. From each tree samples for microscopic examination were taken. (See table.)

After two days a mass of scales was taken from No. 2. In 140 only one was found with the eggs entire, all the others having collapsed.

The appearance of the scales on this tree and on the others, that had not been washed with water, was quite different. On No. 2 many scales were quite black; none where the water struck them had their natural color; all appeared as if rotting, were very loosely adhering to the bark, and could easily be washed off.

On No. 3, at first sight, the scales wore their usual appearance. A closer examination showed many scales loose, but adhering sufficiently to resist ordinary winds in dry weather.

On No. 4 about the same as No. 3. On No. 5 many scales were tightly adherent.

August 23.—On No. 2, where water was applied, many branches are almost free of scale. Examination with a lens showed no living insects. No sign of damage to the tree.

No. 3. Scales are loose and many shedding.

No. 4. Same.

No. 5. Scales are more adherent than on the other trees—2, 3, and 4. A living larva is occasionally seen. From sample of scales taken from No. 5, under the microscope a mass of 164 was examined, of which four had living eggs.

September 8.—No. 2 has shoots on the cleaned limbs. No. 3 shows sprouts on scaly branches; Nos. 4 and 5, no young sprouts.

September 16.—On No. 2, shoots are 8 inches long. There are some on all the others; no sign of increase of insects.

September 26.—The young on all but No. 5 are growing fast. There are some shoots on No. 5.

October 25.—No. 2. No scales on the limbs of this tree. On one twig some few larvæ and some eggs living. The young shoots are 30 inches in length. The limbs that were covered with scales have made a vigorous growth of young wood.

No. 3. Some old scales are still adhering, no larvæ or eggs among them. On some twigs are a very few larvæ and living eggs. The tree looks healthy; has made good growth; from the limbs that were infested, shoots are from one to three feet in length.

No. 4. Some old scales remain, no life among them.

No. 5. A very small number of old scales remain; a very small number of living larvæ and a few eggs were found. The tree has suffered from rust mite. It has made a little new growth.

TREES NOS. 8–20.

September 12.—From a large number of young (four to five years old) trees in a grove, all infested with insects, *M. gloverii* principally, the following were chosen for experiment. All were badly infested; all had

lost wood, but showed signs of healthy roots by sending out shoots from below the parts covered by scales. These trees had been well manured; neglected for some months. The land was poor pine; part dry, well drained; part wet, badly drained; position exposed. A few trees were protected by buildings. Microscopic examination of samples is shown in table; also, after two days, showing disparity already mentioned. A severe storm ended yesterday.

September 25.—Trees Nos. 8 to 17, nearly all the scales are off.

No. 18. Scales black, eggs all living, some larvæ living, tree defoliated, bark burst open, gum exuding, tree badly damaged.

No. 19. Larvæ dead, no eggs dead, tree unhurt.

No. 20. Same as No. 19.

October 24.—Trees Nos. 8 to 20 appear as follows:

No. 8. Label lost.

No. 9. Same.

No. 10. Made large growth, some scales remaining, no recently settled scales, some living larvæ, found only two with eggs.

No. 11. Healthy growth, some small masses of scale remain; no recently settled or migratory larvæ; many living grown larvæ and many living eggs.

No. 12. This was triplicated. 12*a*. Healthy growth, some scales still remain, no living eggs or larvæ found. 12*b*. Nearly clear of scales, found one larva living, one scale with living eggs. 12*c*. Nearly clean, found three scales with living eggs, healthy and vigorous growth of young shoots from what was infested wood.

No. 13. Label lost.

No. 14. Has long healthy shoots, good color, many scales still adhering to old bark, no eggs found, two male larvæ living.

No. 15. Nearly all scales gone, no life in those remaining; tree making young shoots on branches that had lost their twigs, and were themselves covered with insects when sprayed.

No. 16. Scales all gone Tree growing.

No 17. Made healthy growth, some few scales adhering. After long search found no living larvæ; one scale with living eggs.

No. 18. Scales all gone; much bark and half the branches dead.

No. 19. Larvæ and eggs living; no benefit.

No. 20. Large number of larvæ and eggs living; no damage to tree or harm to insects.

OTHER TREES.

All of the trees in the young grove where the trees Nos. 8 to 20 were, except those retained for specimens, were sprayed with a solution of 1 murvite to 10 parts water. Examined October 24. On very few of these trees are there any scales left; all have changed their former sickly color, and the majority have made new growth.

Trees Nos. 21–28.

Eight trees were left in different places unsprayed. October 6, twenty-four days after the others were sprayed, these trees were examined. They had been fair samples of the other infested trees, and showed the extent of damage that had been prevented by the murvite used on surrounding trees. They were in very bad condition; twigs dead; a few leaves at the ends of the branches; no young growth. Microscopic examination showed the presence of an unusual number of parasites and of male insects. (See table.) These trees were then sprayed with a solution of murvite 1 to 40 parts water.

Examined October 24. Storm and rain had bleached the marks on the labels so that they were illegible. Some living eggs and larvæ were found on all; the scales were nearly all remaining on the trees.

The weather was quite cold.

Other Trees.

Many trees with *P. pergandii* were sprayed, but remanded to the genearal list for the reason that no reliable percentages could be obtained, on account of the habit this insect has of forming masses; empty scales, young broods, eggs, are all so joined and overlapped that any attempt to separate only succeeded in taking away portions of individual scales. I ascertained that the application of strong solutions effectually killed both larvæ and eggs, but I usually washed them off with water as soon as they were loosened with murvite.

August 23.—Twenty trees in very bad condition, on well-drained land, have been well cultivated and highly fertilized. These trees were infested by a round scale (*P. pergandii*). There are not very many on each tree; the trees have lost wood; in some instances nearly all is dead down to 2 feet above the ground. Some have lost all the twigs; in all the bark is black and hard. Sprayed with solution of murvite 1 part to water 20 parts.

Seven days later, find the scales loose; fourteen days later, trees showing buds on infested wood; one month after spraying, found shoots growing; two months after spraying, trees growing vigorously. Owner sprayed the entire grove, including these, using weak solution of murvite. I found no living insects on any of the trees.

Table of exact experiments.

Date.	No. of tree.	Insect.	Percentages. Females with eggs.	Percentages. Young females.	Percentages. Males.	Percentages. Parasitized.	Number of scales examined.	After spraying. Date.	After spraying. Days.	After spraying. Larvæ living.	After spraying. Eggs living.	Number examined.	Strength of solution.	Remarks.
Aug. 16	2	M. g.	24	43	27	0	133	Aug. 18	2	0	1	140	1- 5	One part murvite to five parts water.
16	3	M. g.	23	46	26	4	140	18	2	0	4	173	1- 10	
16	4	M. g.	35	33	29	2	153	18	2	0	6	131	1- 20	
16	5	M. g.	29	42	28	1	137	18	2	0	7	145	1- 30	
Sept. 12	8	M. g.	15	32	31	0	161	Sept. 14	2	0	6	123	1- 10	
12	9	M. g.	18	40	33	5	129	14	2	0	2	170	1- 20	
12	10	M. g.	12	47	36	1	143	14	2	0	3	162	1- 30	
12	11	M. g.	12	41	43	1	147	14	2	0	9	180	1- 40	
12	12	M. g.	19	40	31	6	136	14	2	0	23	132	1- 50	
12	13	M. g.	11	51	33	3	171	14	2	0	11	161	1- 60	
12	14	M. g.	10	41	39	2	134	14	2	0	7	173	1- 70	
12	15	M. g.	10	41	18	27	161	14	2	0	10	124	1- 80	
12	16	M. g.	20	50	27	0	173	14	2	0	32	150	1- 90	
12	17	M. g.	21	53	27	1	152	14	2	0	27	163	1-100	
12	18	M. g.	19	60	12	5	158	14	2	*	....	.....	....	Sat. solution sulphate of iron.
12	19	M. g.	24	43	28	2	149	14	2	†	....	.....	....	Sat. solution nitrate of potash.
12	20	M. g.	25	40	30	2	138	14	2	‡	....	.....	....	Sat. solution bicarbonate of ammonia.

* Larvæ dead; no eggs hurt.
† Some larvæ dead; no eggs hurt.
‡ Some larvæ dead; no eggs hurt.

OCTOBER 6.

Numbers.	Destroyed by parasites.	Females with eggs.	Remarks.
No. 21......	Nearly all...	2	These scales were taken in masses of about 100, and the scales containing eggs were counted. The mass consisted chiefly of broken, parasitized, empty scales; some young brood recently settled. No accurate count could be made of any but scales with eggs. Some scales of *P. pergandii* were present. A large number of males had attained their perfect form. These trees were sprayed with solution 1-40; weather cold. Examined October 24; labels were illegible; some eggs and larvæ living were found on all.
No. 22......	....do	3	
No. 23......	....do	0	
No. 24......	....do	0	
No. 25......	....do	3	
No. 26......	....do	10	
No. 27......	....do	12	
No. 28......	....do	0	

REPORT OF OBSERVATIONS AND EXPERIMENTS.

By J. C. Neal, M. D.

Archer, Fla., *October* 10, 1882.

Sir: I respectfully submit reports of experiments upon cotton and orange insects, made under your direction during July, August, and September, 1882.

Allowing me to express my appreciative thanks for valuable aid rendered by you during the progress of the experiments, yours, &c.,

J. C. NEAL, M. D.

Prof. C. V. Riley,
Entomologist.

REPORT OF EXPERIMENTS UPON SCALE-INSECTS AFFECTING THE ORANGE.

In my experiments, under your direction, with kerosene emulsions upon scale-insects, I have tried to find the maximum of destructive value and the minimum of cost.

The *Lecanium hesperidum* and *Mytilaspis citricola* are both abundant in this section, the latter being by far the most destructive. Last winter the cold was so slight that the growth of the scale was not affected, and trees are seriously harmed by these insects that have not been known to be infested since 1853.

I made a series of experiments to determine the value of certain common or native plants alleged to be useful for emulsions. The most of these gave negative results. The *Pteris aquilina* (root), *Sesamum indicum* (leaf), *Hibiscus esculentus* (pod), *Jatropha manihot* (root), and *Maranta arundinacea* (root) were discarded, as being not generally distributed over the State or involving extra labor or expense in preparation. But one proved of value—the root-stem of the *Zamia integrifolia.*

Another set of experiments to find the best proportions of each ingredient of the emulsion, and also the cost, was made.

A large number of experiments were made upon infected trees, with different grades of emulsions to test effects upon trees and insects. Every effort was made to eliminate errors, and I endeavored to make each experiment as complete as possible by repeating it under various conditions.

I found that kerosene combined better with dense and rather warm solutions than if the same were cold or much diluted; and that the zamia and soap solutions were easier to use if kept at a temperature of about 100° to 120° F.

EMULSIONS.

1. Four pounds whale-oil soap were dissolved in one gallon of water, with heat; to this kerosene was added gradually till it was found that one gallon kerosene made a good emulsion, capable of being diluted to 1 per cent. without at once disintegrating.

One gallon of this mixture containing 50 per cent. kerosene costs 30 cents. In several experiments with Lecanium on small trees I tried a saturated solution of tobacco, two pounds to the gallon, to dissolve the soap. This gave good results, but from the extra expense and trouble I abandoned its use.

2. Four pounds rosin soap, common bar or yellow soap, were dissolved in one gallon water. One gallon kerosene gradually added, with constant agitation, made an emulsion costing 26 cents per gallon.

The greater the percentage of rosin in the soap the better emulsion I found it made, which would indicate that such a soap for this purpose would no doubt be a valuable article in this market.

3. Six pounds fresh zamia root were grated and boiled in 3 gallons water, made alkaline by adding 3 ounces "sal-soda." After boiling an hour the mucilage was strained, and while hot one gallon kerosene added gradually, with considerable agitation. Enough warm water was added to make the solution when finished measure four gallons. This formed a smooth, creamy emulsion, quite stable, containing 25 per cent. kerosene, and costing 5 cents per gallon.

MILK EMULSIONS.

1st. With fresh milk.

4. Emulsions containing 25 per cent., 50 per cent., 33 per cent. kerosene were each made, and gave good results. Milk, either fresh or sour, could be used with about the same action.

2d. With condensed milk.

This for many reasons was found most generally available.

Two solutions were made:

a. One pound condensed milk diluted with three pints hot water; to this one gallon kerosene was gradually added, with constant stirring. As soon as the emulsion began forming, four pints water were added and the emulsion completed with brisk agitation. One gallon of this contained 50 per cent. kerosene. Cost, 22 cents per gallon.

b. Mr. Hubbard's formula:

Two pounds milk diluted with six pints hot water. Take six pints of the milk; add, with agitation, one gallon kerosene till emulsified, then add the remainder of the milk and continue the stirring till a smooth emulsion is formed. This also contains 50 per cent. kerosene, and costs 35 cents per gallon.

I experimented with the following dilutions:

Soaps and milk.

a. 1 gallon standard emulsion to 9 of water.
b. 1 gallon standard emulsion to 19 of water.
c. 1 gallon standard emulsion to 24 of water.
d. 1 gallon standard emulsion to 39 of water.

Zamia solution.

a. 1 gallon standard emulsion to 4 of water.
b. 1 gallon standard emulsion to 9 of water.

Values.	Cost per gallon.			
	Whale-oil soap.	Rosin soap.	*a* Milk.	*b* Milk.
	Cents.	*Cents.*	*Cents.*	*Cents.*
a. 5 per cent. kerosene	3	2.6	2.2	3.5
b. 2½ per cent. kerosene	1.5	1.3	1.1	1.75
c. 2 per cent. kerosene	1.2	1.04	0.88	1.4
d. 1¼ per cent. kerosene	0.75	0.65	0.55	0.88

Zamia. *a*, 5 per cent. kerosene; cost 1 cent per gallon. *b*, 2½ per cent. kerosene; cost 0.5 cent per gallon.

COMPARATIVE STABILITY.

After standing 10 days in quiet, the soap solutions in part disintegrated. The oil remained in and through the soap, which formed a gelatinous mass. Heat and agitation reunited the ingredients.

The milk emulsions separated into layers. The serum below easily united by shaking vigorously.

Condensed milk, *a*: in ten days a small amount of serum separated, but oil globules could not be seen; *b* acted but little differently, a trifle less serum.

Zamia.—This in ten days showed no oil globules, but appeared about as well as when first made.

EXPERIMENTS.

1. Fifty large trees badly affected with Mytilaspis. Eighty gallons of dilution *a* of *a* milk were applied with a fountain pump. The second

day the scales were loose, and a week afterward the limbs were free and clean. Many of the leaves dropped.

2. Five large twenty-year-old trees having Mytilaspis; dilution *a*, rosin soap; 30 gallons used; clean within a week; lost most of their leaves.

3. Five hundred small trees, 2 to 4 feet high, affected with the Lecanium; used 100 gallons dilution *b*, whale-oil; scale dead the third day; leaves not hurt.

4. One hundred small trees covered with the Lecanium; sprayed with dilution *a*, Zamia; scale dead the second day.

5. Dilution *d* of *b* milk sprayed on 20 large trees badly affected with Mytilaspis; 100 gallons used. In a week most of the scales loosened, and 50 gallons more used cleaned the trees of scales.

6. Dilution *b*, whale-oil soap; four large trees required but one application to destroy the scale; 12 gallons used of dilution.

7. Dilution *b*, Zamia, one large tree; one application apparently destroyed all scale; 1 gallon used.

8. Five small trees affected with Lecanium needed two applications of dilution *c*, whale-oil soap, to clear the trees.

9. Four large trees having Lecanium; sprayed with dilution *d*, rosin soap. No effect shown the third day. Applied same dilution. Scales loose the second day afterward.

10. Eight large trees; Lecanium and Mytilaspis; 40 gallons of *d*, rosin soap, in which one pound sulphide of potassium was dissolved. Of this one application seemed enough.

11. A large tree badly infested with Mytilaspis. Three gallons dilution *a* of *a* milk destroyed the scale at one application. Many leaves dropped a few days afterward.

12. Four small trees alike affected with Lecanium. Two sprayed with dilution *c*, rosin soap; scale loose the third day. Two sprayed with dilution *c* of *b* milk. A few scales alive on the third day.

13. These experiments were repeated with the general formula of one pound potassic sulphide to 40 gallons of emulsion, with the apparent effect of making a dilution ranking as *d* as valuable as that of the *a* grade.

I think it reasonable to infer from these experiments:

1. The soap solutions are more effective in all grades of dilutions than those corresponding of the zamia or milk; the potash doubtless aiding in softening the scale. In fact, in many cases, strong solutions of soap or potash have been used with good effect upon scale insects.

2. After a rain, or in the evening, all applications are more effective.

3. Two or more applications of an emulsion containing 1 or 1.25 per cent. kerosene are better than a single one of a 5 per cent. or greater percentage of kerosene, and far less liable to injure the foliage. The expense of making and applying the emulsions is often greater than the cost of the material used, and this will most likely cause strong solutions to be in greatest demand.

Experiment 1.—Labor, 90 cents; material, $1.76	$2 66
Experiment 2.—Labor, $2; material, $0.78	2 78
Experiment 5.—Labor, $1; material, $1.32	2 32
Experiment 10.—Labor, $1; material, $2.60	3 60

In one experiment requiring six gallons of the *a* solution the cost per tree, including labor, was: Whale-oil soap, 28 cents; rosin soap, 25.5 cents; "*a*" milk, 15.5 cents; "*b*" milk, 31 cents; zamia, 12 cents.

The preparation called *murvite*, evidently an emulsion of low-grade kerosene or petroleum, has been quite extensively tried. It acts when formed into a solution corresponding to the "*a*" grade, 5 per cent. kerosene, with little or no difference in looks or effects from the same grade of milk.

In many places in Florida the zamia will be found the cheapest agent to emulsify kerosene, it growing in greatest abundance everywhere in the State.

GENERAL OBSERVATIONS ON DESTRUCTIVE INSECTS.

I beg to submit a report upon insects observed as destructive to vegetation in this section, premising that, with few exceptions, the months of February, March, and April are those of greatest insect activity here, and that from lack of time I can do but little better than give a mere *résumé* of what I have observed.

Apple, pear, quince.—The leaves and tender shoots are destroyed by a leaf-folder. The larva folds two leaves together, and with silk, fragments of leaves, and its excreta forms a cylinder in which it remains during the day.* At full size the larva is 11^{mm} long, of a purplish-gray, the head a dull red brown, with a white dot or tubercle like an eye on each side the head, a few scattering hairs over the body. It changes to a chestnut-brown cocoon within its gallery. I have not yet obtained the moth. The apple and quince are of little value here, but the pear is assuming considerable importance.

Banana.—A very small, black, stinging ant† damages the roots, forming a series of rooms, &c., in the older plants.

Grape.—The *Vitis vinifera* and *V. labrusca* both destroyed by a small, gray beetle; the Desmia destroys the leaves; a small yellow and black larva, striped or ringed, comes in platoons on the under side of the leaf. A large gray coleopter‡ with long antennæ is found, and a small larva changing in a white cocoon. A leaf-cutting bee mutilates the leaves, and a small grub-worm bores the roots. I have found no Phylloxera, nor any insects upon the "Scuppernong" varieties.

Guava.—No insects reported.

Loquat (*Eriobotrya japonica*).—A leaf-folder found.

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* Probably *Acrobasis nebulo* Walsh.

† *Crematogaster lineolata* (Say).

‡ Unknown Cerambycid.

Orange, lemon, lime, pomolo-citron roots.—Termites* do great damage at surface, girdling the trees. A black ant† infests any bruised spot, boring into sound wood. Oiketicus girdles small limbs. Scale attacks limbs and foliage; several varieties of grasshoppers eat the tender leaves and angular wood. The *Metapodius femoratus*, *Anisoscelis albicinctus*, and *Leptoglossus phyllopus* puncture the young stems, which soon wither; the larva of the *Papilio cresphontes* defoliates whole limbs, and a small red larva, apparently a web-worm, destroys young trees by eating the leaves and buds.

Mulberry.—I have seen several leaf-rollers, miners, &c., but have no notes upon them.

Oak.—Many valuable shade-trees have been destroyed this season by a borer, that at first destroys a large area of "cambium" around its entrance; then a large hole is bored upward and toward the center of the tree. I have not obtained it. Another borer attacks the roots, or at the collar. The young limbs are infested by a very large scale and plant-lice, the leaves by various Tortricids, Geometers, &c.

Pine.—Scale on the young limbs, Lophyrus on the leaves, and a worm that bores the terminal bud and is very destructive to the regular growth of young timber.‡

The larvæ of *Sphinx coniferarum* are occasionally met with. The larvæ of Buprestis, "the Sawyer," destroy many trees. Entering a growing tree from a place bruised or hacked, they soon destroy the "cambium," and one tree thus infested apparently communicates the insect to others not previously harmed. The pine is also injured by many other insects not yet examined.

Persimmon.—Often defoliated by a Clisiocampa (?) and a leaf-roller. The Japanese varieties are infested with a white mealy bug or scale.§

Peach.—Leaves eaten by a worm; scale‖ very bad on oldish trees, often destroying an orchard; young leaves infested by Aphides, stem injured by *Ægeria exitiosa*, and a Buprestid borer. Lice on roots, and also a larva of a beetle. Fruit occasionally harmed by a worm.

Plum.—Early leaves often covered by Aphides. Leaves eaten by larva of *Papilio cresphontes.*

Artichoke.—Tops infested with Metapodius and Leptoglossus. Tubers eaten by Termites.

Beans.—Roots often thickened, spongy, and filled with lice. Stems bored out near the ground by a small, bright green larva, causing rotting of the stem. Leaves eaten by Seirarctia larva, Eudamus, and several Tortricids. Pods punctured by a gray Lytta. Seeds eaten by a beetle and weevil.¶

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* *Termes flavipes* Kollar.

† *Crematogaster lineolata* (Say).

‡ Probably a *Retinia*.

§ *Dactylopius*.

‖ *Lecanium persicæ* Bouché.

¶ *Silvanus quadricollis* Guér. and *Calandra oryzæ* (Linn.).

The prevalence of the stem borer and the Lytta renders this crop very uncertain.

Beet.—Almost a failure, owing to a worm that rolls up leaves and stems of young plants into a slimy bundle.

Beans.—Pods and flower-stems infested by a brown beetle; seeds eaten by a small white worm that makes its cocoon from a dozen seeds webbed together.

Cabbage.—Early plants destroyed by a black beetle, often destroying hundreds of plants. Last season I lost 5 acres by the *Mamestra picta*, *Plusia brassicæ*, Aphides, and Pieris, and a tiny beetle, jet black, that bored into the stalk near the root. Have not seen the Strachia.

Chufa.—Roots infested by the Termites.

Corn.—Larvæ of Elater and a boring beetle destroy the corn at joints.

Sorghum.—Larvæ of Agrotis injure the young plants.

Broom-corn.—Larvæ of Heliothis attack leaves, buds, young shoots, silk, and young ears. Weevil very bad in young corn.

Cow-pea.—Same troubles as beans, *q. v.*

Cucumber, *Melon*, *Squash.*—Agrotis often takes a crop on old land. Lice destroyed the whole growth this year. The Phakellura bores young fruit; the Anasa not common.

Okra.—Leaves eaten by a larva looking like *Anomis erosa*.

Peanut.—Larva in pods. Leaves eaten by Eudamus.

Potato.—Leaves eaten by the gray Lytta.

Sweet potato.—Leaves eaten by various leaf-rollers and the *Macrosila cingulata.*

Tomato.—Leaves eaten by the Agrotis and *Macrosila quinquemaculata.* Fruit often nearly a failure from the attacks of the Heliothis.

Turnip.—Leaves eaten by a black, tiny beetle, as well as the other insects that affect the Cruciferæ. Termites and a small black ant eat the roots.

The Scale, Orange dog, and Grasshoppers on the orange; the Heliothis and weevil in corn and sorghum; the Pieris and Plusia to the cabbage and cauliflower, and the Aletia to cotton are the greatest insect enemies we have to fight in this section.

It is no exaggeration to say that the Heliothis and weevil destroy half the corn crop of Florida.

The above report seems meager, but with the experiments my time has been limited.

ADDENDA.

The "murvite" costs $1 per quart at Gainesville. This makes a 5 per cent. solution cost 40 cents per gallon; 2½ per cent. solution cost 20 cents per gallon; 1.25 solution cost 10 cents per gallon.

The small yellow ant is a terrible pest to housekeepers, invading houses and destroying all meats, sugar, lard, &c., that it can get into. It renders entomological research often futile. I have many times obtained a fine larva, and after feeding it a day or so, have found it nearly eaten by these pests; it is necessary to put the vivaria on legs, and then in kerosene, to keep out the ants.

Fleas.—These appear in February, March, and to June, then disappear until the next February—rather singular.

Mosquitoes and gnats found here only during the rainy season.

Blind mosquitoes occur in such numbers in July as often to fairly fill the air and cover the walls of houses.

Ticks very common in summer on cattle.

Chigoes, red bugs, common in hammocks around rocky points, rotten logs.

OBSERVATIONS AND EXPERIMENTS UPON THE COTTON-WORM.

The theory that the Aletia, as a perfect insect, survived the mild winters of Florida, was, I think, demonstrated as correct by finding the hibernating moth in wire-grass fields early in this year, and later by finding its eggs upon leaves of rattoon cotton in this neighborhood, and the moth in April upon sirup-painted fences.

The frost of December 7, 1881, destroyed the Aletia, larvæ, eggs, and pupæ, in pine-land fields, but in sheltered hammock locations I found larvæ as late as January 3, 1882. That morning a temperature of 30° F. destroyed all larvæ in this section.

January 15 and January 21 I saw the Aletia moth in fields that were being burned off, but not again till in April.

During November and December, 1881, and September of this year, I repeatedly buried pupæ in both dry and moist earth; but from several hundred thus treated no moths escaped.

One inch of even loose sand prevented them from gaining the surface; and of dozens brought me by planters during February, that had been plowed up, none proved to be Aletia, but were different species of Noctuids.

During the months of May, June, and the first weeks of July, I made strenuous exertions to obtain larvæ or perfect Aletia, but with no avail. I visited field after field, especially points that had first shown the cotton-worm last year, and hammock fields that were usually forward in

growth, and spent several days in careful search, but though finding occasional traces of larval action, no Aletia or larvæ were obtained.

During July, about the 10th, I was advised of the finding of a few cotton-worms, about 24 miles southeast of Archer, and August 1 I found a single full-grown larva in a field near Archer, but a close search showed no others discoverable in that field.

About August 10 the larvæ appeared in force 10 miles southeast, and almost simultaneously 10 miles north, of Archer.

Since then their progress has been extremely erratic. In fields side by side, one would be destroyed, the other hardly disturbed. In one case a track from east to west was destroyed. This was in the center of a large field, and about 150 feet wide; the sides of the field remaining were but slightly damaged.

In this case I could see no reason for such action; there was no perceptible difference in soil or cultivation.

By August 26 the cotton-worms were in fields 9 miles from Archer, north or south; August 30 they were 4 miles each way, and, though I caused careful examination and offered rewards, no larvæ or moths could be found in intervening fields.

September 2, I found larvæ 3 miles southeast; and on the 24th, I noted a few larvæ in near-by fields.

The prevailing winds during August and September have been from the east and southeast.

South and west of Archer is a long line of barren sand hills thinly timbered and with but few planters. Though but 5 miles from Aletia-infested fields, no cotton-worms were found this year or last in these localities.

August 10, I visited a plantation 9 miles southeast and found small larvæ. August 18–20, all were pupæ, and from some dozens of pupæ obtained August 20, moths appeared August 26–28.

In this case the pupæ remained but six to eight days.

In many fields this year a gray fungoid growth appeared in small patches upon the under side of the cotton leaves, attacking generally the thriftiest plants. In these places the larvæ seem to lack vitality, soon becoming yellow and dying before pupation. This disease has not been noticed before this year, and does not act like the "rust" usually found in worn-out land.

In many places I found an apparent antagonism existing between the Aletia and the cotton-stainer (*Dysdercus suturellus*). In fields infested with both insects, but few and often no Aletia larvæ could be found where the cotton-stainers were in any great numbers. This may, however, be only a coincidence.

In one field I found that the guinea fowl had rendered most efficient service. The cotton presented a singular appearance; the upper portion of the plants nearly leafless, the lower limbs green and vigorous.

The martins and the bull bat are of little apparent service to the cot-

ton planter, as the martins leave this section during the full moon of August, and the bull bat some three weeks later, or about the average date of the greatest activity of the Aletia.

The loggerhead shrike has been frequently seen to devour both larvæ and pupæ of the cotton-worm, and may be well classed as especially valuable to the planter.

I had the pleasure of seeing a small, green tree frog make a good meal from the larvæ, and as this and several species of lizards are very frequently observed in the cotton fields, it is reasonable to suppose them quite destructive to the larvæ.

The following spiders I have collected upon cotton: *Epeira fera*, *Misumena vatia*, *Attus audax*, *Argiope fasciata*, *Oxyopes viridans*, *Gasteracantha*. The Attus and Oxyopes I have observed preying upon larvæ.

Three if not four varieties of ants are found upon cotton. A very small, jet-black ant; another black ant, called here among the blacks "the little men," very ferocious, and giving both bite and sting, often called the fire-ant; a light-brown ant, and a tiny, reddish ant called the sugar ant. This last is very destructive to molting larvæ or exposed pupæ, and many instances have occurred indicating that they devour the eggs of the Aletia.

I think most of the wasp family, with bees, ants, and other insects, are attracted to the nectar glands of the cotton, and in fact in this section most of the honey obtained in this season is from the cotton-plant.

I have noted at least three species of Polistes, two of Vespa, and two of Sphex preying upon cotton-worms.

The "hornet" has annoyed me considerably by seizing worms that I was colonizing for experiments, and carrying them away, and later in the season, last year, I saw the smaller "yellow-jacket" destroy many pupæ, or begin by biting a piece from an exposed surface of a pupa; the ants then would soon carry off the contents.

The large, black-bodied wasp (Polistes) destroys great numbers of molting or prepupal larvæ. One bite to each, in the side, a sip of the exuding fluid—nothing more, but the mortality from this cause fully equals all others.

The Asilid flies—three species, *Proctacanthus milberti* (?), *Laphria thoracica* Fabr., and *Diogmites discolor* L., are very common, and the Laphria does rapid and effective work now in destroying all sizes of larvæ. The Proctacanthus, early in the season, was useful in preying upon small grasshoppers that were defoliating cotton and young orange shoots. Often I have caught this fly on the ground struggling with a grasshopper at least double its size. The smaller fly (*Diogomites discolor*) is extremely active and predaceous, and I have taken it while destroying Podisus, Nezara, and *Anisoscelis albicinctus*, and one while piercing a small Dragon-fly.

Parasites have been unusually plentiful this year. At least 40 per

cent. of pupæ that I had saved for various purposes were destroyed by Pimpla, Tachina, and Sarcophaga.

Parasitized larvæ were easily distinguished by sluggish action and a change of color to yellowish green.

As a means of prevention in Florida, and perhaps applicable to other sections, I would suggest destruction of cotton to prevent rattooning, and late planting for some years.

It will readily occur to one as reasonable that if all cotton-stalks were uprooted by January 1st of each year, and no seed planted till March, the chances of survival of the hibernating moth would be at the minimum.

A singular experiment was tried this year, with apparent success. During June, July, and August a number of stumps and log-heaps were left slowly burning near a cotton-field so that the smoke would drift over the field at night. All other fields in the neighborhood are devastated, while this field is green and, except at the western edge, shows no action of Aletia.

This instance seems suggestive. Did the creosote from the smoke in some measure poison the cotton, or was the smoke obnoxious to the moth?

In some cases where I find the *Palma Christi* growing in cotton-fields there appears to be a scarcity of the cotton-worm in the vicinity, which may suggest its value as a protection.

Jute has been abundantly tried, but with no effect perceptible, and this season I could not induce any planters to accept seed and try the experiment again.

KEROSENE EMULSIONS.

As directed, I have confined my experiments to emulsions of kerosene, and noted the effects of applications of such solutions upon the cotton-plants and cotton-worms.

My efforts were made to determine: 1. Substances best adapted to emulsify kerosene; 2. Maximum dilution of kerosene destructive to the larvæ; 3. Minimum dilution of kerosene destructive to the cotton-plants.

It was soon apparent that kerosene could not be used to advantage simply with water, from its tendency to collect at the top; nor if the water were made slightly alkaline or acid would much benefit be observed.

A strong solution of various soaps made a good emulsion, presenting some points of advantage.

Soda soap, potash soap, whale-oil soap, and other varieties were tried, but a cheap grade of yellow bar-soap, especially one in which rosin was largely used, proved best, and suggested the manufacture of a soap containing a still larger quantity of rosin, which could be cheaply sold for this purpose.

After many trials I found that 4 pounds of this soap to 1 gallon of

hot water would emulsify 1 gallon kerosene, forming a gelatinous compound that was quite stable.

Less than this percentage of soap acted badly with kerosene, and a greater amount did not appear to emulsify a large amount of kerosene.

This mixture, containing 50 per cent. kerosene and costing 26 cents per gallon, I adopted as a standard.

I prepared the following dilutions:

A. One gallon standard solution to 24 gallons water, 2 per cent. kerosene, cost 1.04 c. per gallon.

B. One gallon standard solution to 39 gallons water, 1.25 per cent. kerosene, cost 0.65 c. per gallon.

C. One gallon standard solution to 49 gallons water, 1 per cent. kerosene, cost 0.52 c. per gallon.

D. One gallon standard solution to 79 gallons water, .625 per cent. kerosene, cost 0.325 c. per gallon.

E. One gallon standard solution to 99 gallons water, .5 per cent. kerosene, cost 0.26 c. per gallon.

Emulsions A, B, and C presented a milky color, and were quite permanent; D and E showed some tendency to disintegrate after four days' standing.

I tried solutions of many native plants, and found the zamia finely adapted for an emulsion, especially when used immediately.

Six pounds of zamia "roots" were washed and grated. The pulp boiled an hour in 3 gallons of water; then strained, and while hot stirred in 4 ounces sal-soda. This emulsified 1 gallon kerosene, forming a beautiful pinkish jelly, containing 25 per cent. kerosene, costing 6 cents per gallon. One gallon of this solution was added to 24 gallons of water. This emulsion contained 1 per cent. kerosene, and cost 0.24 cents per gallon.

Dextrine, starch, flour, mucilage of bene (sesamum) leaf, mucilage of root of *Pteris aquilina*, and other substances were tried, but proved to be of little value.

Milk emulsions.—By gradually adding, with agitation, one gallon kerosene to one gallon fresh milk, an elegant emulsion was formed that bore dilution well, but as fresh milk is often not attainable the condensed milk was used, and the following seemed most easily made:

One part condensed milk dilute with five parts water; to this add gradually eight parts kerosene, with vigorous agitation. When the kerosene disappears, add three parts water, and agitate till a homogeneous emulsion is formed.

This is more pleasant to use than soapy solutions, and costs—

	Cents per gallon.
Standard solution, 50 per cent. kerosene	22
Dilution A′, 2 per cent. kerosene	0.88
Dilution B′, 1.25 per cent. kerosene	0.55
Dilution C′, 1 per cent. kerosene	0.44
Dilution D′ 6.25 per cent. kerosene	0.225
Dilution E′, 5 per cent. kerosene	0.22

The A′ and B′ were not stable longer than two days; the remaining dilutions barely one day.

With the exception of the zamia emulsion, all others were better to use the day of manufacture.

A mixture called murvite was sent me for trial. It gave similar results to the milk emulsions, when diluted in a corresponding manner.

Effects upon the cotton-plant.—These varied greatly, owing to the weather subsequent to the application.

Emulsions A and B, A′, B′, 1¼ to 2 per cent. kerosene, did not harm the cotton-plant if two cloudy or showery days followed their use. A bright sunny day scorched the tips and edges of the tender leaves badly. Emulsions C, D, and E, C′, D′, E′, produced no bad results upon leaves or bolls, and were repeatedly tried, with uniform effects.

Effects upon larvæ.—1. I colonized five hundred full-grown larvæ upon five cotton-plants, and sprayed them with emulsion A, soap series. In five minutes forty larvæ dropped off the plants, trembled, and soon died; in an hour but one hundred remained, none feeding, all hanging from the stems and leaves; in three hours but eight survived; the next day all were dead, and the cotton-leaves badly withered.

2. I prepared forty gallons of solution B′, milk, and sprinkled thoroughly one-fourth acre of cotton. The stalks average seven feet in height, and the worms were very plentiful.

The next day apparently but one in each hundred were living; the day following that the difference was quite marked, and at this time, three weeks afterward, the surrounding cotton is defoliated, the sprinkled section remaining vigorous and green.

3. I colonized one hundred larvæ, all ages, on a cotton-plant; sprayed these with solution C′, milk; fifteen worms fell off in twenty minutes; the remainder quit feeding. The next morning but two remained, feebly alive.

4. One hundred large larvæ were colonized and sprayed with solution D′, milk. In ten minutes ten dropped off; in half an hour but thirty-five showed vitality; in four hours all were dead.

5. One hundred larvæ, small size, were sprayed with one per cent. kerosene-samia emulsion; all died within an hour.

6. One hundred small larvæ sprayed with emulsion B, soap, died in one hour.

7. Three hundred large larvæ were sprayed with solution C′, milk. The next day but twelve showed signs of life, and they were evidently moribund.

8. Three hundred large larvæ were sprayed with the zamia emulsion; all died within four hours, and the repetition of experiment 3 with this solution gave better results than with milk or soap emulsions, the zamia perhaps contributing some toxic action.

I repeated these experiments with all the emulsions till satisfied that

an emulsion of one per cent. kerosene, thoroughly applied, was fatal to all larvæ it reached, and harmless to the cotton-plant.

I noted that as soon as sprinkled the small larvæ stopped eating, straightened, and quickly fell to the ground. Older larvæ would tremble, evacuate fæces, and hang suspended some time. The anal extremity lived longest.

The addition of one pound sulphide of potassium to forty gallons of any emulsion seemed to increase the rapidity of its toxic action, but it is objectionable as to smell and its destructive action upon rubber hose. The sulphides will bear further study.

Still, with all these emulsions, their cheapness and safety, I have a grave doubt as to the applicability of any to long-staple cotton.

I tried a number of experiments to determine the minimum quantity needed to thoroughly spray an acre of cotton during August or September. In one very carefully conducted experiment I found most of the plants averaged 6 feet high, in rows of 4 feet apart, and 2 feet between the plants in the drill.

In this case 160 gallons barely sufficed for one-half an acre, and as it could not be applied from a cart it was hand-carried. Two field hands required four hours to complete the experiment.

The labor of preparing solutions, and of carrying and using a fountain pump, will prevent small farmers, especially colored people, from trying these remedies.

The cost of this experiment was, 160 gallons solution C′, 70 cents; labor, 60 cents, or $2.60 per acre, and with the close margin between profit and expense in cotton-growing, this slight cost will deter many.

Invasions of cotton-worms in October do but little harm. The larvæ feed only between the temperatures of 72° and 92° F. The night temperature of October averages 65° to 68°, and the larvæ remain quiet till the mercury stands at 72°. At 50° the larvæ rapidly turn yellow; at 45° they swing helpless from the leaves and soon die.

The pupæ survive 35° if shaded from the sun and the cold does not last more than a few hours.

Early in the season the Heliothis destroyed at least one-third the cotton-bolls, and now cotton-planters complain of the cotton-stainer. These insects have done more damage here than all the Aletia. In many cases the young bolls are found filled with the weevil (*Sylvanus quadricollis* Guér.) and small red worms (*Batrachedra rileyi* Walsingham), and planters believe that tiny worms act independently of the Heliothis. These larvæ are described on page 98, Patent Office Report, Agriculture, 1855.

The larvæ of the *Agrotis* (generally *annexa*) do some damage to early cotton—February-planted—and two or three species of grasshoppers and crickets at one time threatened the destruction of the entire crop. Plant-lice were not so numerous, for some reason, on cotton, though whole crops of melons were destroyed by one species of Aphis.

In several instances I noted a small gray coleopter (*Epicauta strigosa* Schön.) devouring pollen and the base of the stigma of the cotton-flower. Some such action, no doubt, as well as that, well known, of the Heliothis, destroys the smallest bolls.

The *Anisoscelis albicinctus* (Report of Agricultural Department, 1875, page 119) has been seen puncturing the cotton-bolls and young shoots, and is very destructive to the tender orange twigs. The cotton-stainer (*Dysdercus suturellus*) also aids in the destruction of small cotton-bolls.

In several instances I observed larvæ infested with an exceedingly small "mite," which soon produced death. I have not been able to fully make it out, but it appears to be an active, yellowish louse infesting the larvæ when full grown.

As to the question of an alternate food-plant, I have as yet found none in Florida, but will investigate further.

REPORT OF OBSERVATIONS AND EXPERIMENTS ON THE COTTON-WORM (ALETIA XYLINA).*

BY PROFESSOR R. W. JONES.

OXFORD, MISS., *January* 11, 1883.

SIR: The spring of 1882 was not favorable for the early planting of cotton. Cold, wet weather delayed the work of farmers very generally. When the plant came up, it seemed to display less vigor than usual, grew slowly, and early in the season it suffered much from the Cotton-Louse (*Aphis*). It was, therefore, later than usual when it attained its full growth and commenced fruiting. The autumn, however, was favorable. There was nothing to interfere with the growth or to arrest the fruiting until November 13, when the thermometer fell to 37°, and the night of the 14th it went down to 28° F. This qualification of the above statement should be made, viz: that from the 19th to the 21st of October, inclusive, the nights were cool, the thermometer falling on the 21st October to 46° F.; but vegetation was unhurt, and whilst the worms seemed somewhat chilled early in the morning, they did not fall from the plant, and as the sun warmed the earth and air they resumed their activity.

In October we had the unusual phenomenon of the leaves finishing their growth, thickening, withering, and falling, without having been touched by frost. They seemed to fade, to become sear, and to die simply because they were no more able to perform their function. Their work was done. Quickly new buds, leaves, and stems were put forth, and on this second growth of tender leaves there was a large brood of Aphides, differing in appearance much from those in spring. The color was dark, the legs long and black. These Aphides, as well as those in spring, were attended by immense numbers of ants.

In the spring and throughout the summer the ants were mostly the small red ant, known as the house ant, *Myrmica molesta;* there were a few black ants a little larger than the red.

In the fall, on these new leaves, and attending the dark-colored Aphides, were three varieties: (1) The small red. (2) A black ant twice the length of the red. (3) A brown ant nearly thrice the length of the red, with an abdomen more enlarged and rounded than usual, and exhibiting clear spots.

* Professor Jones was instructed to continue experiments with insecticides upon the Cotton-Worm, and to report in addition upon:

1. The real influence of ants upon the Cotton-Worm.
2. Work of other enemies of the Cotton-Worm.

The Cotton-Worm (*Aletia xylina*) appeared in this vicinity the latter part of August. In many other parts of the State it appeared earlier, and had a much longer time to depredate. I traveled along the line of the Mobile and Ohio Railroad, stopping at half a dozen places, and found the worms in some places in the prairie in large numbers and doing considerable damage in August. I did not revisit that section, and therefore do not know to what extent the ravages were pushed. At that time the conditions there, as well as here, were most favorable to the multiplication of the insects; it was very warm, and rain was falling at very short intervals. Whilst the cotton there was late in starting and the fall was favorable for its maturity, the Cotton-Worm had an unusually good beginning and prospect. The indications at that time were that much damage would be inflicted by them.

The field near here, in which I first found the worms, and in which I observed them through the season after their appearance, was one that had been *cultivated negligently*. There was in it a large quantity of "crab grass," which furnished lurking places for moths. Other fields separated from this by only a short distance, in one or two places only by a fence and road, were scarcely attacked at all. I inferred from what I saw that careful, clean cultivation contributes largely to the immunity of the crop from the depredations of these pests, and therefore pays. Most of the land in this field is undulating; a small part lies along the bed of a stream which flows freely in winter and spring, but becomes dry in summer; this is flat, level land. The undulating land was a sandy loam, quite open, porous and friable, allowing water to sink through it with great ease. The bottom had somewhat more of stiffness and compactness. I am thus careful to mention the characteristics of these soils, because it would appear that the undulating lands would furnish more favorable habitations for ants and some other insects supposed to devour Cotton-Worms. It is a fact that the undulating lands had far more ants than the "bottom"; but it is also true that there were more Cotton-Worms on the undulating lands. Where the ants abounded, there the Cotton-Worms abounded also. This fact contradicted my expectation, but the fact stands true nevertheless. I have no explanation of the relatively diminished numbers of worms on the flat lands, unless the following observations account for it: (1) The cotton was larger on the level land, the leaves larger, coarser, and apparently tougher. (2) There were many more spiders on the lowlands. Several times I saw spiders eating worms as they became quiescent, having spun a few threads about themselves and rolled the leaf just before becoming pupæ.

During the warm, wet weather in August and the earlier part of September the worms increased rapidly, especially on the undulating lands. Before the middle of September the weather became settled, clear, and warm. When the second brood of worms formed moths, thousands of them could be found in the daytime concealing themselves in the dense and tall grass that had grown on the cotton-rows, and yet the next

brood of worms was small. I watched closely, trying to discover the cause of the diminution. I conjectured that ants were devouring the young worms, and gave them close attention. One day I saw two small red ants (*Myrmica molesta*) bring a half-grown Cotton-Worm down the stalk of cotton. Upon examination I found the worm had been wounded, apparently it had been pierced, and it was almost dead. I could not tell whether the injury to the worm had been done by the ants, or whether they had seized it after it had become helpless. After this, although I watched closely, with the impression on my mind that ants did in all probability destroy worms, I found at no time ants attacking or devouring them, nor did I see any indications to this effect. When I saw lines of ants traveling through the cotton-field I frequently disturbed their movements by breaking up their path in some way, and then I frequently put pupæ and larvæ within easy access. Again, I oftentimes put worms and pupæ near them on the ground without disturbing them in any way. I also brought worms, pupæ, and ants to the laboratory and imprisoned them together, meanwhile feeding the worms. The cotton insects suffered nothing from the ants. I saw repeatedly ants eating the cast-off skins of worms and the chitinous integuments of pupæ from which the moths had bursted. I saw ants around the eggs of Aletia, eating them; I think they eat the fresh eggs; I know they eat the membrane that covers the albuminous material of the egg, and I am pretty sure, from all I saw, that they devour the whole egg. This would explain the small brood of worms coming from such a swarm of moths, and I think this is the way they check the multiplication of this enemy to the cotton crop.

EXPERIMENTS ON THE EGGS.

I frequently brought into the laboratory leaves of cotton bearing eggs of Aletia. The walls of the laboratory are thick, and the temperature there is never very high, even in midsummer. These leaves I disposed of in two ways: First, I put some in glass jars, on which ground-glass plate covers were lightly laid; second, others I shut up in cylindrical tin boxes, holding about a pint each, with tightly-fitting tops; these boxes were such as those in which buhach is sold. Of those put in glass cages none of the eggs ever hatched. If they did I could not find the worm. The leaves quickly wilted, turned dark, and after a while became black, giving off the odors of decomposition.

On the leaves put into tin boxes eggs hatched, and the worms were fed until they reached full growth, webbed up, and formed moths. When the tops were put on tightly the atmospheric communication between the inside and outside was very slow. The moisture and color of the leaf were retained for many days. These caged larvæ got no light, except when the tops were removed for taking out the refuse matter and the introduction of fresh food. It seems fairly inferable that, first, no very high temperature is essential to the hatching of the

eggs; and, second, that light is not necessary to this, nor to the growth of the larvæ. I put some larvæ in a glass bottle and stopped it air-tight. They died in twenty-four hours.

TACHINÆ AND ICHNEUMONS.

During the month of October I think at least *half* the Cotton-Worms I saw bore the eggs of parasites. Of these I sent specimens to you several times and they were pronounced *Tachina aletiæ* Riley, and *Pimpla conquisitor* Say. Since they were determined by yourself, and have already been described by you in Bulletin No. 3, I need add nothing except my testimony that they are most effective checks to the multiplication of Aletia. I did not see them until the latter part of September; they were on two broods of worms. Generally there was only one egg to a worm, occasionally two, quite rarely three or four. I put many of these parasited larvæ in cages and fed them; never yet have I seen one bring forth the Aletia moth, but always there comes instead the imago of the parasite. When occupied by the parasite, the pupa case becomes darker than when the Aletia pupa is alive, and the case loses those bright yellow circular bands which it shows when the pupa is alive.

The first week in November I found crawling on the ground a half-grown worm which bore a cluster of eight eggs. These eggs had not the appearance of those of the parasite above mentioned; they had a clear greenish hue. I sent it in a wooden box by mail, and regret that when the box reached you the worm was not found. I saw no other parasite eggs like these.

The brood of worms which followed the appearance of *Tachina aletiæ* and *Pimpla conquisitor* was very small. The cool nights from the 19th to 21st October did them no apparent injury, and their destruction must have been due to these parasites.

My observations did not discover any insects that depredate on Aletia other than ants, spiders, Tachinæ and Ichneumons.

BOLL-WORMS.

During August and September, Boll-Worms (*Heliothis armigera*) did much damage here. In August, next day after a rain, I saw a green soldier-bug (*Raphigaster hilaris*) almost concealed in a hole made by a boll-worm. I let it remain in the field for a time, watching whether it would destroy the worm. I then brought it to the laboratory and fed the worm on bolls for five or six days in a cage with the bug. No injury was done the worm; it reached its full size and went down into the ground. I left the bug in the cage, and it died. It evidently fed on excrement and the contents of the boll, which decayed because of the perforation by the worm.

PREPARATIONS FOR DESTROYING THE WORMS—PARIS GREEN.

I employed this mechanically suspended in water, 1 pound to 80 gallons, to which a little flour paste had been added; it killed the worms

pretty generally after they had eaten it. The same is true of arsenite of potash dissolved in water.

Some persons here employed London purple, and reported adversely on it. They applied it while the rain was falling daily, and without any paste to give it adhesiveness to the leaves.

I also used sulphate of zinc, 1 pound to 40 gallons of water; this killed 10 per cent. of the worms, but it is easily washed from the leaves, because of its ready solubility in water.

PYRETHRUM.

I made experiments this season with this vegetable substance, which confirmed what had been said and written in regard to its remarkable insecticide properties; indeed, nothing that I have seen or handled is comparable to pyrethrum for quickly and safely destroying the worms. I found that the powder suspended in water and sprayed on the plants is almost as effective as the carefully prepared and subsequently diluted alcoholic extract.

I planted the seed you kindly sent me last spring, and have now some healthy plants growing; these have not yet bloomed. I will report further in regard to them hereafter.

I made infusions and decoctions of the following:

1. Boneset (*Eupatorium perfoliatum*), one ounce of dried leaves to a pint of water.
2. *Euonymus*, one ounce of dried bark to a pint of water.
3. *Solanum nigrum*, dried leaves, stems and berries, 2 ounces to a pint of water.
4. *Solanum aculeatissimum*, as No. 3.
5. *Solanum pseudocapsicum*, as 3 and 4.
6. China berries (*Melia azederach*), as 3, 4, 5.
7. Mock-orange fruit (*Prunus caroliniana*).
8. White clover (*Trifolium repens*), two ounces to a pint of water.

These preparations were carefully made and as carefully applied. They exhibited no insecticide properties either by contact like Pyrethrum, or by consumption, like arsenic.

I think it is not necessary for me to go into particulars in regard to the preparation and mode of application, except to say that I followed the usual methods, as prescribed in Parish's Pharmacy and other similar works, and employed a fountain-pump with fine rose.

Of the Solanum berries I made alcoholic extracts, and used these also, after diluting them first with ten volumes of water, and afterwards with only five. These proved as valueless as the effusions and decoctions.

I have the honor to be, very respectfully, &c.,

R. W. JONES.

Prof. C. V. RILEY,
Entomologist, United States Department of Agriculture.

REPORT UPON THE COTTON-WORM, BOLL-WORM, AND OTHER INSECTS.

By Judge LAWRENCE JOHNSON.

HOLLY SPRINGS, MISS.,
October 10, 1882.

SIR: Commencing July 1 to make diligent inquiry, by voluntary newspaper articles and otherwise, concerning insects injurious to cotton and other crops, I found, this season, the northern belt unusually free from our insect enemies. The first complaints, and the only ones heard this month, were from the gardens. In these the European Pieris had made an early appearance, the striped Diabrotica had made cucumbers and melons impossible, and *Strachia histrionica* had never left them from the fall preceding. These pests are mentioned because only on them could I try poisons at that time.

My first experiments, to prepare an emulsion of kerosene, were only partially successful—I should say failures. Application of my imperfect emulsion to cabbages was the nearest to success. It effectually killed the worms whenever sufficiently applied from a small sprinkler, and did *not kill* the cabbages, nor always injure them. But every effort to help the squashes, cucumbers, and melons killed the plants or failed to scare the Diabrotica. The emulsion was mainly applied to the earth around the plants. The beetles would come out of the loose ground and fly away, but would be found again on the plants. They were specially destructive to candytufts on a border. The earth of the whole bed being very loose, they could easily shift their hiding places. Pyrethrum powder was most successful against these, but it had to be renewed frequently and of a greater strength than for caterpillars, one to ten of flour being found about right, blown on by a small bellows offered in market for the purpose—that is, the drug stores which sell the powder generally have the bellows also.

The most obstinate pests were the Harlequin bugs (Strachia). If pyrethrum ever killed them, I never found it out. Though the tincture applied to cabbage-heads seemed to sicken them and drive them out awhile, I never got it strong enough, or it was too volatile to be effectual.

Kerosene emulsion will kill these bugs if it can be applied to the abdominal portion of their bodies. But there is the trouble. A mere wetting of the leaves, which can generally only reach the upper surface

and the axillary portions next the stalk, scarcely ever catches one of them. They are shy, and dodge around like squirrels on a tree. War must be made upon them by co-operation of all the gardeners of a vicinity, and winter, in this latitude, is the time for the campaign. The burning of the trash and litter on the surface before breaking up will destroy many. But their great asylums are the green plants so common here. Lettuce and many kinds of mustard grow in Mississippi during winter in the open air, and the great southern crop of greens (collards), whether standing out or sheltered, fosters the bugs. But the great nursery for them, sorry to say, is the horseradish. Many gardens here have luxuriant bunches of horseradish, giving them an air of life in the dead of winter. If I can only be at home this winter, I shall not forget to give this evergreen a plentiful taste of kerosene.

No Cotton-Worms (Aletia) were heard of in this northern portion of the cotton region until about the 15th of August. When summoned to the spot, twelve or fifteen miles south, I found a second brood in full force; more probably this was a third. A very simple calculation showed that they must have been colonized there as early as the middle or last of July. The planter on whose lands they had first begun was a gentleman of uncommon intelligence, and a good, successful farmer, but neither he nor his tenants had noticed the worms until, as if by magic, they were scattered all over his fields and his neighbors'. No instance better illustrates the value of the advice you have so often given to planters of the middle and northern cotton belts—to look out for the first patch of ragged leaves, or, better still, even before that, to notice for the first spotted foliage. It was not difficult to convince this gentleman, and even to find the *spot* in his field where he might at one time have covered the whole army with two or three tablecloths; and this, I think, was as early as the 1st of July. What a pity in this case, when I was on the inquiry and lookout for a chance to experiment. An ounce of Paris green or London purple or a half-pint of kerosene would have saved these two or three counties north of Tallahatchie River some thousands of dollars.

Let me dwell on this a little longer for another reason—really important to these people—and that is to fix the time of the first visitation of the worm. When I found a small spot in this field, and, as it happened, at a distance from the path which traversed it, where, from its blackened appearance, one would have thought the cotton dead or eaten with rust, with no leaves, and only a moderate supply of bolls at the bottom, it was not difficult to detect the work of Aletia, and to fix the date about the middle of July. The eggs, then, were laid probably as early as the 1st; and this was the work of one moth. She had been driven before the prevailing southwest winds for miles, and, weary, put out her whole brood, of possibly 500, on the first spot where she found undisturbed repose. This is the earliest date I have ever been able to fix with certainty. It shows that the cotton planter even this far north

must begin his vigilance by the 4th of July. The crops are laid by about this date, and a season of rest and negligence occurs on the southern farm. To guard against this danger, a part of this grateful rest must be given to inspection. The first mother moth is apt to lay her eggs all near together, or, if disturbed, does not fly far. The worms being thick, and occupying small territory, are easily destroyed.

When I reached the field of battle they were scattered for miles and only a few in a place. To see the effect of the kerosene I was compelled to collect the worms from a considerable space around, to the stalks I proposed to sprinkle. This was September 5, having received information only a day before, whilst preparing to go farther south. In no one spot could I find them thick, or army-worm fashion, yet there were very few fields, or spots in the fields, in which worms or pupæ were not to be found, and the flies were literally everywhere. At night the flies came in numbers wherever there was a light. When pointed out to the people the general information was that that particular fly had been around the lamps for a month. This agreed well with the information of Mr. J. Walker, on whose place they first appeared. It was about the middle of August they (he and his tenants) first oberved the ragged leaves in numerous localities, and the last of August before worms were noticed by farmers a mile or so further off. The worms then observed by farmers, the 10th to 15th of August, were a second brood, and those I found at work September 5th must have been a third generation. To have combated the evil at this date would have required considerable outlay and horse apparatus for poisoning the fields. I could get none of the planters to try it, because of the general impression at this date (5th to 15th of September) that the worms were not injurious. In fact, many rejoiced to see them. They regarded them as checks to the luxuriant growth of weeds and leaves, and thought they would promote opening of the cotton, generally so backward. An early frost would have caught the most of the cotton unopened. As it actually turned out, the fall was very late and protracted into even the usual winter, and if the worms had been kept back, the *top crop*, which not often matures here fully, would have been enormous.

Experiment No. 1 was made with a very weak kerosene emulsion: 60 parts of water to 1. The emulsion itself had been prepared with 1 quart of oil to 1 pint of milk. More milk was added to perfect the butter—about half pint, warm. This application killed all the worms sufficiently wetted with it; cotton leaves and stock thoroughly drenched without any apparent injury; surviving worms next day found feeding on leaves as if nothing had happened.

Experiment second: Same with 30 parts of water. The least drop of this on a worm sickened him. So many were killed that the few escaping I concluded had not been touched. Practically, but few of the leaves could be wet on the under side. I used a fine fountain pump, of patent 1878. But many of the leaves were found spotted from the kerosene. My emulsion, I fear, was not perfect, and probably had some free oil.

In progress of this experiment I observed something that may be of interest. Pupæ were numerous, and most of them were inclosed in a half roll of the leaf, as usual. The liquid, applied generally to the leaves, was seen to run down into these nests, and many of the pupæ were set to wriggling. I then gathered a great many of them, and tried the emulsion on them, of various degrees of strength, and applied in different ways: First, of this strength (30 to 1), thoroughly wet by hand or dipping them in the liquid; all died; stronger solutions the same; weaker not tried. Secondly, a dozen, gathered with the stalks, so as to leave them hanging, as in the patch, in a cluster, were sprinkled, as in the field, and then caged. Within a week two flies came out. The cases whence they issued were found not saturated with the oil. All the others exhibited traces of oil, and, though perfectly dead, showed no other signs of disease or parasites, and very little progress towards putrescence.

I thought these two last experiments worth reporting, as they may have a bearing upon the destruction of chrysalids of other genera.

But my conclusion I think it also proper to state. Although much of it may be considered deduction from imperfect experiment, I do not perceive any hope of kerosene competing with the arsenious poisons for cotton-worm: 1st, it can never be so cheap; 2d, it must *touch* the insect to be effectual. Paris green sticks to his food, and whenever he eats leaf enough he must die. I think, however, for cabbage worms and any collections of caterpillars the kerosene is the thing. I intended to try it on some social caterpillars I found congregated on hickory trees, but in one night after finding them they had completed their moult and dispersed. Circumstances then intervened which prevented my identifying my interesting hickory worm.

I have many chrysalids of Aletia yet, which I keep dry, but otherwise exposed to the climate, to see how they will winter.

There is only one other set of observations to report upon; and, looking at its barrenness of results, this deserves no notice. For several days and nights I had good opportunity to watch the moths of the cotton field. The owner of a perambulatory sorghum mill and evaporator was at work in one corner of a cotton field from 5th to 15th of September. I took up my camp with him. The nights and mornings were unusually cool. In the very early morning hours I could find nothing, see nothing. The habits of *Aletia*, which I was after, remain still a mystery as to my skill. But I can say that up to 10 or 11 o'clock (p. m.) they were astir in clouds. Attracted by the fires at the sorghum works, they perished in countless numbers. But nearly all of those examined at the mill were males. The operator told me that where he had last made up a crop of the cane, somewhat farther south and west, the flies had been so numerous as to compel him to cover up his evaporator and suspend work until morning. The nights at that time were warmer.

[A severe malarial attack at this time (18th September) put a stop to this kind of investigation.]

After the 1st of October, being engaged in geological work, it was my fortune to travel eastward and southward; you may believe I did not forget the Aletia. It may be of interest to record the fact forced upon me that, after six or eight miles to the east of the Mississippi Central Railroad, I found no more Cotton-Worm north of the Tallahatchie River. I do not say none were there, because people take so little trouble to publish facts of the kind, but it does seem highly improbable, or I would have seen or heard of them. All that was peculiar, that might have acted as a barrier, was the unbroken line of forest, never less than one or two miles in width, constituting the growth of the river bottom. As soon as I passed south of this barrier, at New Albany (some 40 miles east), I got into the paradise of Cotton-Worms. They were everywhere, and increased in their pernicious effects as I advanced south. Yet not before I reached the middle belt of counties did I find farmers estimating the damage as anything considerable.

I cannot close this rambling, garrulous communication without a word about my old friends the Heliothids. They were exceedingly numerous in gardens and corn during the summer, but comparatively light on cotton. Probably this happened from there being a great deal of late corn, and because cotton was also late. Yet I satisfied many farmers that the damage done to what they call the *middle crop* early in August was beyond calculation. Not for this, though, have I referred to them, but to question the utility of lights to attract and destroy them, so commonly recommended in agricultural papers. At my sorghum camp I never saw a single Heliothis; not because there were none in the fields and woods. The worms of all ages could be found in the corn, whether hard, or late and young, and many in the cotton; not so numerous as they had been in July and August, but during the whole of September the flies could be found in the cotton fields. I have watched them by the hour slowly flitting from plant to plant, from about 4 p. m. till dark, capriciously tasting the secretions of nectar, or dropping an egg in a bud or square; but after dark I never was able to find one, on the wing or at rest. I had often noticed before that, though my window opened low, and into the garden infested with these moths, it was not common for one of them to come to the light.

And apropos to the question of their food-plants, I think I can add to the list the tree *Cercis canadensis* for the early spring, and among late summer and fall plants the varieties of *Penstemon*, so abundant in our woods. I did not *verify* my worm by rearing it to the imago in either case; but surely I cannot be mistaken in the larva and in his manner of work. Besides, during the latter part of the summer and fall I have frequently found the moth, in the woods, flying most commonly about different species of the low herbaceous Scrophulariaciæ. Once I found the worm (if not greatly deceived) nipping out the top bud of a Penstemon. And I am now disposed to think that *budded* grasses—that is, with the top, when about to shoot up to bloom—eaten out was Heliothis'

work, instead of Laphygma, to which I had formerly ascribed it. The latter, I must remark now as a later reflection, I never have found solitary in habits. They go in families more or less numerous.

Little as I have accomplished, I trust you will not find it altogether worthless; and that another season, whether in your service or not, I shall learn something more for the cause of science.

Believe me, ever, most respectfully, &c.,

LAWRENCE C. JOHNSON.

Prof. C. V. RILEY,
Entomologist.

P. S.—Referring again to my summer notes, I find some views of Mr. J. M. Brooks, an intelligent planter of Waterford, in this county, on the treatment of Heliothis. He says, "*Worm* your early corn as you would tobacco. It is not half so tedious, and a great deal more effectual." He thinks that for two years he has greatly diminished their depredations by this means. One more adjunct he practices and recommends, and that is to keep hogs in plenty, and as soon as cotton is picked out put them in the fields. It is curious, he says, how they will take to the rows, and almost plow up the old stalks in search of grubs and chrysalids. This latter I have witnessed myself. They certainly must get a good many cut-worm pupæ; I fear Heliothids generally go too deep for them

Again, truly, &c.,

L. C. J.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 2.

[SECOND EDITION.]

REPORTS OF OBSERVATIONS

ON THE

ROCKY MOUNTAIN LOCUST

AND THE

CHINCH BUG,

TOGETHER WITH

EXTRACTS FROM THE CORRESPONDENCE OF THE DIVISION ON MISCELLANEOUS INSECTS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 18, 1883.

Sir: I have the honor to submit for publication the second Bulletin from this Division, prepared under your instructions.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. GEORGE B. LORING,
Commissioner of Agriculture.

INTRODUCTION.

This Bulletin includes the report by Mr. Lawrence Bruner of his observations in the Northwest during the summer and fall of 1882; some memoranda of experiments with kerosene emulsions on the Chinch Bug by Prof. S. A. Forbes, State Entomologist of Illinois, and which he has kindly sent to the Department because undertaken at our suggestion; and extracts from the correspondence of the Division.

The general scarcity of the Rocky Mountain Locust (*Caloptenus spretus*), observed by Mr. Bruner in the regions explored, tallies with the observations made by others in the West and Northwest during the same period, so far as we have any knowledge thereof. Dr. C. A. White, on behalf of the Geological Survey, traveled up and down the Yellowstone Valley for 100 miles from its confluence with the Missouri; 50 miles up and down this latter stream, from the mouth of the Yellowstone, and 50 miles east of Glendive, on the line of the Northern Pacific Railroad. During this field-work he very kindly made observations on *C. spretus*. Very few were seen near the mouth of the Yellowstone, and but a few in the air during a portion of a single day in the latter part of August. No memorandum of the direction taken by these was made. Prof. Samuel Aughey has also furnished the following notes:

On June 21, 22, and 23, I was in the North Loup Valley, between Saint Paul and Ord, and beyond, 35 miles. During these days a few locusts were flying from the northwest towards the southeast. A few dropped here and there, so that there was no mistake as to the species. There were not enough to do any material damage even had they all alighted. I have made diligent inquiry in all directions, but failed to find where they migrated to. Some cow-boys whom I met stated that a few hatched in the sand-hills south of the Niobrara, or between the latter stream and the headwaters of the Loup. If this could be confirmed it might be inferred that those seen migrating came from that locality.

On August 21, I encountered a few locusts on top of Rattlesnake Mountain. Said mountain is 85 miles or thereabout north of Rawlins, on the Union Pacific Railroad. Height of mountain, 6,900 feet above sea-level (by my barometer). They were coming from the northwest.

A week later I found a few scattered over the ground at the head and along the valley of Powder River. I also found a very few on September 2, near Searght's Ranch, on the North Platte, about 35 miles north of the mouth of Sweetwater River.

This is a meager account, but I was on the lookout all the season, and found no *Caloptenus spretus* elsewhere.

Dr. H. A. Hagen and Mr. Samuel Henshaw, who were also out during the same period on a tour of investigation for the Northern Pacific Railroad, in Montana and Washington Territory, have informed us that,

though diligently looking for this particular locust, and inquiring of all settlers about it, they found comparatively few, and heard of nothing as to its injuries during the year. These facts, together with Mr. Bruner's full report, justify the belief that the Western farmers have little to fear from the inroads and devastations of this pest the present year, 1883.

In the general correspondence of the Division there is frequently matter and experience of interest and importance both to agriculturists and to entomologists. In these bulletins, in the future, we propose to make use of such as would seem worthy of publication, giving both the letters and the replies thereto in as condensed form as possible.

C. V. R.

REPORT OF OBSERVATIONS IN THE NORTHWEST ON THE ROCKY MOUNTAIN LOCUST.

By LAWRENCE BRUNER.

WASHINGTON, D. C., *December* 1, 1882.

SIR: Herewith I submit a report of my trip to the Northwest during the past summer, made under your direction, for the purpose of procuring additional data and facts in reference to the history and habits of the Rocky Mountain Locust (*Caloptenus spretus*), and particularly such data as would permit of definite conclusions as to the prospects for the year 1883.

In company with Mr. J. H. Mockett, jr., of Lincoln, who acted as my assistant, I left West Point, Nebraska, on the 20th of June, going by rail to Bismarck, Dakota, and from this point proceeded by river to Fort Benton, Montana, stopping off at such points as we thought would be of interest in the furtherance of our projects.

On our arrival at Fort Benton we learned that the only practical route by which to reach Fort McLeod, British America, was by stage direct from this point. We accordingly chose this means of reaching that point, knowing that, although not exactly what you desired, it would take us through at least a portion of the country suitable for and at times occupied by *C. spretus* for breeding grounds.

On reaching Fort McLeod we found matters so entirely opposite to what we had anticipated they would be, that we not only deemed it desirable, but also profitable, to ourselves to seek quarters outside of military reign and closer to the mountains. We accordingly embraced the first opportunity, and went up to the old Government saw-mill, 45 miles to the westward, where we went into camp. At this locality we remained four weeks, devoting the time to the objects of the trip. Here we also had a boat built in which to reach the lower Saskatchewan. Of course we might have accomplished the same object by team with guide and outfit; but we concluded that this would have been too expensive in this region. The river journey also offered several inducements that the other did not, viz., an opportunity of examining the country on both sides of the river, while, at the same time, all risk of losing the outfit by theft, which would be liable to occur by team, was avoided.

After proceeding along the Saskatchewan as far as the mouth of Seven Persons' River, we came to a settlement called Medicine Hat. Here we learned that Fort Walsh could be reached without difficulty

After several days' halt we succeeded in securing the use of a team and driver with which to reach a point from which we could again reach settlement. We therefore abandoned our boat and started across the country. On arriving at Fort Walsh we replenished our provisions. From here we struck off across the country to the eastward, and after a tedious drive of ten days reached the end of the track of the Canadian Pacific Railroad. Here we took the cars, by which we reached Winnepeg, and subsequently home.

It will be seen from the above sketch of our trip that a considerable portion of the country which you had mapped out as being worthy of traversing previous to my starting was not reached. This was in part unavoidable, on account of the difficulty of obtaining means of transportation, and also on account of the limited amount of funds at my disposal.

Throughout the country which we did examine, however, the surface characteristics were much as indicated in the large map published in the second report of the Commission, especially as to the burnable and non-burnable portions.

In making this trip I was aided materially by the liberality and kindness of the following companies, corporations, and individuals:

The Saint Paul, Minneapolis and Omaha Railway Company, for half-rate fares for myself and assistant; the Northern Pacific Railway Company, free pass for self and assistant; the Coulson Line of steamers, reduction in rates; Colonel Chipman, commander at Fort Buford, for hospitalities and other favors; United States Quartermaster Department, for transportation on steamer General Sherman; Lieutenant Robinson, at Rocky Point, for hospitalities; I. G. Baker & Co., at Fort McLeod, for favors.

I must not forget also to mention the officials here in Washington, who kindly furnished me with letters of introduction.

The report, as you will notice, is in the form of a diary for the first few pages, after which it takes the form of a narrative.

Respectfully, yours,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
United States Entomologist.

Sioux City, Iowa, June 21, 1882.—Reported case of broom-corn and sugar-cane saving corn and vegetables from the attack of *C. spretus* (D. H. Talbot). One case of this kind noted by above-named gentleman, and tried by another to whom he (Talbot) imparted the information, with like result.

The manner in which the first case was arranged is as follows: On the north was first planted a strip of broom-corn; next potatoes and vegetables, or only potatoes; next to the potatoes was a strip of sugar-cane and then vegetables, after which came corn. It is claimed that

when the locusts struck the northwest corner of the field as they came from that direction with a northwest wind, they drifted by to the west, avoiding all that portion of the field to the leeward of the sugar-cane and broom-corn, but taking everything clean diagonally across where the field was unprotected by these two plants; the supposition being that the wind in passing over these plants carried with it something offensive either to the sense of scent or taste of the locust. The wild grasses of the genus Sorghum, of which several varieties occur in the West, are also shunned by this insect.

Mr. Talbot also claimed that quite a number of young locusts had hatched and were now hatching in the hills lying to the east and north of Sioux City.

Had not much time or would have gone out and examined them to see whether or not they were *C. spretus*.

Bismarck, Dak., June 24.—To-day we were out on the hills in the vicinity of the city, and found some *C. spretus*, mostly all fledged and in healthy condition; a few other species, as *C. occidentalis*, *Hippiscus coralipes*, *Stenobothrus*, &c. *C. spretus* is quite common but not numerous; no damage anticipated.

Between Bismarck and Fort Buford, at various wood-stations, *C. spretus* and other Caloptenus larvæ and pupæ were noticed, but nowhere in great numbers. At Fort Buford, June 29 and 30; young locusts of numerous species quite plentiful in the hills and flat lying to the north and northwest of the post. *C. spretus* most numerous where vegetation is rankest.

Geometrid larvæ found on a wild gooseberry bush in hills north of here.[1] Yucca moths (*Pronuba yuccasella* Riley) quite abundant on blossoms of *Y. angustifolia;* also several species of ants that appear to congregate for sweets exuded by plant. None of latter saved.

Some Meloidæ found on the blossoms of sunflower and thistle.[2] Also one species of Bee-fly.[3] Latter quite common though not abundant.

Lepidoptera quite scarce. Only a few diurnals noticed, chiefly *Pyrameis huntera.*

June 30.—Collected, on low grounds near the river, some Cleridæ on flowers. Also some Hymenoptera from weeds, where they were apparently for the purpose of destroying insects. *Caloptenus bivittatus* quite common, and even numerous at some places on the bottom lands where they feed upon rank vegetation, weeds, &c., just as they do in Nebraska and Iowa.

Mosquitoes numerous enough to interfere with work; very ravenous in the attack. Old settlers, however, mind them but little.

Fort Buford, July 1.—Were in hills north of here, and found some interesting *Cicindelidæ* among ravines in bad-lands, quite numerous

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[1] *Eufitchia ribearia* (Fitch).

[2] *Epicauta sericans* Lec. and *E. callosa* Lec.

[3] Species of Systoechus and Triodites.

but hard to capture on account of their activity.[4] No locusts except natives and a few *C. spretus* not yet fledged.

Noticed to day for the first time the possibility of the common Prickly Pear or Leaf Cactus being insectivorous in a measure. When anything touches the stamens while spread, they all close very quickly and retain it within their grasp until a peculiar viscid secretion is ejected.

July 3.—Visited again the bad-lands in quest of the above-mentioned Cicindelidæ, and succeeded in obtaining a few additional specimens. As noticed before, they were very hard to capture.

On the 4th saw a few locusts in the air—not more than two dozen. They were flying north.

DESCRIPTION OF THE COUNTRY AT AND ABOUT FORT BUFORD.

The surface at Buford is quite level, and is covered well with grasses. A few miles (varying from two to three) back from the river the surface becomes rolling, and gradually very rough and almost destitute of vegetation, forming what is known in this vicinity as "bad-lands." There were locusts at this locality during the summer of 1878, though in what numbers and particulars of flights I was unable to learn. Also in 1873.

Bad-lands comprise the water-worn edge of a high plateau that extends northwest and southeast for several hundred miles. This plateau is well grassed and watered during the fore part of summer, and affords an excellent breeding ground for various species of locusts. In the fall of the year, and even in late summer, this entire country can be burned over.

On approaching Mouse River Valley the bad-land feature is again presented, and forms the eastern escarpment to this plateau—"Plateau du Coteau du Missouri." Of course spring burning could be very successfully done here, especially if the growth standing was that of two or more years. That *Caloptenus spretus* does occasionally breed over this entire region in great numbers there can be no doubt, but that it is not a permanent place of multiplication seems evident from the data obtained while at Fort Buford.

In reference to the possibility of this insect continuing to breed in this locality from year to year, or for an indefinite period, I must confess that I cannot see why it could not, unless it be in the variability of humidity during different seasons.

After leaving Buford the surface along the Missouri River differs but little from that farther down the river, sometimes widening into extensive and fertile valleys, and at other places closely hemmed in by the towering buttes and water-worn hills. The Missouri winds its way through bad-lands or plateaus, the edges of which are "bad-lands."

The formation of which the surface deposits of this section of country are composed is that of a vast shallow inland sea at times, and at others

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[4] *Cicindela cinctipennis* Lec.

of brackish or other marshes, in which, or around which, grew luxuriant forests, the remains of which are now to be seen in the numerous veins of lignite coal that are exposed wherever the edges of hills have been worn by water, and also in the numerous petrified trunks of trees that are imbedded in the soil of the bluffs.

At various localities these imperfect coal veins have taken fire and so baked the overlying clay as to render its color that of brick-dust. This has occurred either by accidental fires or, oftener, by spontaneous combustion caused by the chemical action inherent in the alkali soil of which the over and under lying strata are composed.

Up the river from Fort Buford this formation is gradually replaced by one of different character. The whitish bluffs are replaced by those of a darker color, and those the character of which is quite different. Instead of being sharp-cut, they are more rounding and almost entirely destitute of vegetation, the only plants being a few small species found chiefly on the sea-beach or on alkali flats. The soil is very loose and fragile when dry, and exceedingly tenacious when wet. It is what is known as *gumbo*. Throughout this formation from top to bottom are found many concretionary rocks that have for nuclei various species of Cephalopod mollusks, as Ammonites, Scaphites, Baculites, &c.

The surface of this formation affords but poor footing for the multiplication of locusts. But as the mouth of the Mussel Shell River is approached, these characters become less permanent, and small areas of good grass are to be seen on the uplands and gently sloping hills that lie on each side of the river. Here, too, in some of the deeper and more shaded cañons, are to be seen small clumps of pines and juniper trees. At this locality we can truthfully assert that sometimes *C. spretus* breeds. The farther this way (up stream) we come, the more pines and grass—good grass on bench-lands. Numerous locusts of different species are found here. The farther up or the closer you draw to the mountains, the more numerous become the species and individuals of these native locusts. No specimens of *C. spretus* were seen this side of the Little Rockies. True, that form known as *Melanoplus devastator* is frequently to be met with along the river bottoms among the rank vegetation, where its habits resemble those of *C. differentialis*. It seldom alights upon the ground, always jumping from one plant to another, as do various species of Acridium.

At Rocky Point, or what is known as Broadwater's Landing, we laid over a few days in order to visit the Little Rocky Mountains and the country adjacent to them. At this locality are numerous exposures of the Cretaceous rocks—very likely that group known as the Fort Pierre. Throughout the clays of which this formation is composed are great quantities of gypsum and concretions, in the center of which latter are various species of shells, &c. Like the greater portion of the country already passed over, this vicinity also partakes of the "bad-land" character, though it contains a few small groves of pines that tend to diminish the monotony.

July 11.—Early this morning we started for the Little Rocky Mountains, which lie about 25 or 30 miles to the northward. In going out to them we at first wound about among the pine-dotted hills for three or four hours, and finally came out on a high plateau covered with good grasses. This sloped gradually back to the base of the mountains, where it is quite well watered by various small streams that issue from the cañons and sink into the adjoining flats. There are several thousands of acres of good grazing land, with smaller areas capable of tillage, in the immediate vicinity of the mountains, but as the plains are traversed the soil becomes less fertile and more arid as well as alkaline.

Away from the mountains the summer rains are few and the winter snow-storms severe. While this section appears to be pretty well interspersed with bad-lands and alkali wastes, it is in reality one of the best grazing regions in Montana, being the chief winter range for the buffalo and antelope, as well as other game.

During the present and for several seasons past but very few migratory locusts have been noticed here or at any point between the Missouri and Milk Rivers, but during the years of great abundance of these insects this locality was one of its favorite haunts. Other species were never very numerous, and at times are even scarce.

This season I was unable to find more than two or three dozen specimens of locusts during the day and a half spent in collecting at this point.

These mountains are well timbered in most parts, but not with trees of large size or free of limbs. Other vegetation (as shrubs and herbs) is quite abundant, as in all other mountainous or rolling countries where a considerable amount of rain falls. The rocks are chiefly slates, sandstone, and limestone, and show some signs of volcanic action. There are some quartz leads bearing traces of iron, lead, and copper, as well as some of the precious metals. There are several thermal springs in the vicinity of the highest peak of the range. This peak is the only one which we ascended, and that only a little over half way up. We gave this peak the name of our esteemed chief, who has done so much in ascertaining the facts and in solving economic problems in reference to the Rocky Mountain Locust. *Riley's Peak* stands out in front of the main range near the head of Little Rocky Creek and to the right—one of the most imposing land marks for many miles about. It was on the lower slopes of this mountain that we killed two bears—one Silver-and tipped, the other a Cinnamon—after an exciting skirmish with three of these denizens of the mountains.

These springs of which I spoke above are not hot, but of about the temperature of brook water in summer.

Our collections at this point were small, as insects of all orders appeared to be very scarce.

July 17.—To-day our journey lay along a piece of river very much superior to that passed heretofore. Numerous signs of volcanic action

were present on all sides; great crevices were filled with dark basaltic columns, and walls of the same were at many points objects of much interest and comment to the passengers.

This evening, at the mouth of Judith River, while taking on wood, I noticed a great many yellowish-green larvæ feeding on almost every variety of vegetation to be found at the locality. The willows (*Salix longifolia*), however, seemed to be its favorite food, as they were completely defoliated. I do not know what species the insect was, but have sent some on to Washington.[5] At this same locality I noticed two specimens of *Caloptenus* very closely allied to *spretus*, if not this insect, but could not get them, as they jumped away and were lost among the rose-bushes.

July 19.—To-day landed about three miles below Fort Benton, and walked up to town over the bluffs on the north side of the river. Saw a great many insects of different kinds, and collected some. Locusts much more numerous here than below. No migratory specimens among the other forms, but a few that appear to me to be new to science.

During our stay at Fort Benton much of our time was occupied in collecting the various locusts to be found in the vicinity, and also in looking for Yucca moths, &c. No data in reference to locusts additional to those already possessed from this locality. On our trip to McLeod we occasionally saw specimens of a large, dark-winged Œdipoda-like locust[6] as well as a few others which we could not stop to capture; but very few of the migratory kind among these. Country between Benton and McLeod is all high, dry, and alkaline, and is for the most part an excellent breeding ground for all kinds of locusts. The water in a great many of the isolated springs contains a large per cent. of sulphate of magnesia, and hence is very trying on the traveler, since it is the only water to be obtained. The grasses over this stretch of country improve in quality and length as we move northward, and also as we approach the mountains.

The general surface is comparatively smooth and slopes gently away to the east, only becoming broken and somewhat barren in the vicinity of the rivers and deep coulées, where the features of the bad-lands of Dakota and Eastern Montana are again repeated, though in a less degree. This entire section at a period not long past was literally overrun by buffalo, and hence can be relied on as a splendid stock range. Where buffalo range, the winters, though at times cold and severe, are comparatively free from snow, and hence are suited to winter grazing.

August 3.—Here, in the vicinity of Fort McLeod, there is a great variety of native locusts, and on the flat, stony grounds to the southwest they are quite numerous. They are mostly Œdipodinæ, with a few forms of Acridinæ. While on our journey to the mountains west of Fort McLeod we succeeded in capturing a great many of them that

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[5] *Zerene catenaria* (Cramer).

[6] *Circotettix carlingiana* Thos.

were afterwards destroyed by mice during a stormy night, the tent having blown down and everything overturned. Did not get a chance to replace them afterwards, as we were kept busy arranging for our trip across the country to Winnepeg. No migratory locusts noticed.to-day.

The country in this vicinity is very similar in appearance to that passed over in going from Fort Benton to this point, but, being closer to the mountains, it becomes slightly rolling, and at the same time more thickly covered with vegetation, since the rainfall is more frequent. The surface, however, in many places is very thickly covered with small stones and bowlders. Of course, where such is the case, the soil is poor and the grasses thin and short, making excellent breeding spots for various species of locusts. These, too, are not overlooked by them, as can be seen from the numbers of these insects to be found on and in proximity to such spots. Here, too, we miss to a great extent many of the alkali signs so prominent out on the plains. The magnesia salts are less strong where found in springs, and the marine vegetation, *i. e.*, salt marsh and beach plants, has entirely disappeared from among the flora of the country, and hence also maritime insects are no longer to be noticed.

As we approach the mountains, more and more marked become these differences. Trees begin to be seen, shrubs and herbs become more numerous and common, and the number of flowering plants increases. It must necessarily follow that insect life also increases. This is true, for now various species of bees and wasps make their appearance among the flowers, and an occasional yellow butterfly is seen flitting across the green sward. Now and then the note of a solitary sparrow is heard, or perhaps some snipe or plover is seen running along the ground chasing a locust, or sailing gracefully in the air, uttering its sharp notes to its mate and young. By this time we have reached Pincher Creek, a small mountain stream along which are settled several ranchers who appear to be doing well. This stream heads far up in the foot-hills, where it is fed by springs and lakes filled with beautiful trout. The bed of the creek is crowded with bowlders and the stream is very rapid.

After crossing over this stream we begin ascending towards the first range of foot-hills, or "hog-backs," a series of which extend in a nearly parallel direction with the main range. These small ridges are composed of a kind of sandstone that has been tilted up edgewise—the softer strata having been worn away and the harder ones left standing, and thereby causing the various ridges, one in front of the other. These various ridges are dotted here and there with groves of quaking aspens, willows, and spruces, and at other points the trailing juniper almost entirely covers the rocks. Numerous small and sparkling springs discharge their cool, limpid waters among the rich grasses that carpet the valleys and lower hillsides, all tending to make the vicinity attractive and beautiful. Here it is that we find great variety in the insect life, every little variation in surface and altitude offering some peculiar at-

traction to certain species of insects. Hence this will be a splendid collecting ground, and we will undoubtedly find some interesting forms.

Our camp was made about midway from the first of these "hog-backs" to the first low range of mountains on the bank of Mill Creek. This stream is a beautiful one, and flows through a rocky cañon that is quite picturesque with scenery. The stream heads way up among the timbered portions of Victoria Mountain, and forms a way for running the lumber material down to the saw-mills situated at the lower end of its course.

Hymenoptera are not numerous in species, but quite plentifully represented in individuals, the most attractive being the various species of humble bees and hornets which frequent flowers. Of these insects there are quite a number of gaily-colored forms, of which we obtained a fair series. Ants, too, are very numerous, but few in species. These are chiefly under stones, but two or three species frequent decayed logs or burrow in the earth, and form hills of sticks and small stones. From some of these we obtained several parasitic beetles—one form, of which there are very likely two species, being a "pill-beetle," and the others small Staphylinidæ and allied forms. Of these we also obtained a fair representation. Orthoptera were common, and of a fair number of species. These, of course, we tried to obtain in all their varieties.

One misfortune against which we had to contend, and which I regret very much, is the loss of a large number of our pinned specimens, by mice, thus making it quite difficult to classify from alcoholic specimens alone. I had made it a point to pin all odd or new looking forms, in order to retain as nearly as possible their original colors, and as there were some of which I only obtained one or two specimens, or representatives, these are lost. Others, again, change their colors to such an extent after immersion in alcohol as to render them unrecognizable when seen fresh.

Among these were numerous forms of Caloptenus (Melanoplus), some of which very closely resemble the migratory species in many of their characters, though differing sufficiently not to be confounded with that insect. None of these, though watched very carefully, exhibited the migratory trait, except, perhaps, *Camnula atrox*, which is quite common on some of the hay flats. It did not, however, appear to gather in great numbers, or to move in unison as does *C. spretus*. None of their movements noticed by me could strictly be called migrations; but at various times I saw individuals or even small groups of them rise several yards into the air and move to some other locality from fifty feet to a hundred or more yards distant.

Such species as we found identical with those in the Western and Middle States differed in no respect from them in habits, and hence were but sparingly collected, save perhaps in a few instances.

There are some Pezotettigos that may be new. These appeared to be rather rare, and were only found high up in the mountains, and quite a

distance from camp. In habit they closely imitate *Pez. dodgei* and *Pez. obesa.* One peculiarity of all the Acrididæ of these mountain regions appears to be the great variability in coloration among different individuals of the same species. Just what the cause of this phenomenon is I was unable to learn, but that there is cause for such variations there can be no doubt.

Other orders of insects are not very numerous here, save, perhaps Diptera and Heteroptera, and these are only numerous in individuals—the species being comparatively few. Of Diptera we noticed a few and collected such as may feed upon the eggs of locusts. Of Homopterous insects, and also those belonging to Neuroptera, we saw but very few; of these, however, we collected what we well could.

During our stay in these foot-hills we made many excursions into the surrounding country and mountains, each time finding something new or of interest. These trips were generally but of a single day's duration, as we were without horses and were obliged to return to camp at night. It was by means of these trips that we visited quite an extensive area of country, the surface of which is much varied. We therefore, without much doubt, must have obtained a fair representation of the most common forms of the insect fauna of this region.

It may appear incredible that there were so few species of Lepidoptera where so many and such beautiful flowers grow, but such is the fact. During the month that we spent collecting here we could not have seen more than seventy-five or one hundred butterflies and moths, and these all belonged to less than a dozen species.

Having remained at this locality a month, we now started for McLeod with our boat. The start was made from the mouth of Pincher Creek, going by river about 75 miles. After an exciting run over numerous rapids and shoals we reached our destination just after sunset of the same day. After lying over for three days in order to lay in a supply of provisions and other necessary articles for our down-river trip, we pulled out on the afternoon of the 4th day of September. This undertaking was one which very many advised us not to try, as they claimed that the river over a great portion of its course was unexplored and might prove to be treacherous. However, we thought we would run the risk.

When we left McLeod our intention was to run as far down as the first settlement, or the first place where we could obtain transportation across country to the Assiniboine or Qu'appelle River, it being our intention, if possible, to make a portage and reach Winnepeg by these rivers in our boat. The first opportunity, however, came much sooner than we had anticipated, and much more to our desire, as it gave us an opportunity of visiting the country lying in the vicinity of Fort Walsh, as well as that to the eastward, where the great swarms of locusts of 1875 and 1876 were bred.

Before recording the occurrences of this trip, perhaps it would be

well to give the facts in reference to several interviews that I had with old settlers in reference to the movements and breeding of the migratory locust in this Northwest Territory. The first of these interviews was with Mr. William S. Gladstone, an ex-employé of the Hudson Bay Company, who first came into the country in the year 1845, and was stationed at Edmonton House. He stated that in the year 1843 some locusts were hatched as far north as that place, and also at several subsequent periods, but he did not remember dates. Could not be positive as to the directions of their flights, but knows that they did fly away. Once or twice they were quite numerous, but did no damage, as there was no chance for them to do so, there being no farming done in the country at the time.

During the summers of 1874 and 1875, locusts were quite numerous throughout all the region in the country around and between Forts McLeod and Walsh. They hatched all over, even as far north as the Red Deer and beyond. They appeared to come from the east, and to leave towards the south and southwest. These were the movements as noticed on the St. Mary's River at old Forts Hoop-up and Slide-out, trading-posts. No special notice was taken of them at this time, as every one then in the country was occupied in traffic with the Indians, and had no time to watch grasshoppers. The country away from these trading-posts, too, was wild and unknown to whites and not safe to travel through, hence the little known in reference to matters foreign to trading with savages. Since the mounted police came into the country, every season more and more of this wilderness became known and traversed, until at present there are but few localities unexplored.

Mr. Gladstone's observations in reference to the habits of the locust are substantially the same as those we made while the insect was with us.

The prevailing winds are from the west and southwest, and the climate is more mild as the mountains are approached; the cause of this feature being the influence of the "Chinook" winds that at various times during winter are wafted across the mountains from the Pacific coast, and also the sheltering influence of the pine and spruce forests as well as of the mountains themselves.

Mr. Davis's (of I. G. Baker & Co.) statements were substantially the same as those of Mr. Gladstone; therefore it is unnecessary for me to repeat them here. He, too, was stationed at the same localities, viz, Hoop-up and Slide-out.

Since the spring, or rather summer, of 1877, no locusts were seen in the vicinity of Fort McLeod, *i. e.*, not in numbers sufficiently great to cause alarm or even to damage garden vegetation, nor were any noticed in the air as far as I was able to learn.

From these data and from what observations we made individually, I would infer that at present the Northwest is comparatively free from this plague.

It is unnecessary for me to enter into a lengthy discussion here as

to the possible or probable causes for the sudden and general disappearance of this insect at this time from this vast area of country that in every respect is so admirably adapted to its increase in the greatest numbers possible; for we already know how general had become its distribution during the years 1875 and 1876, and how, in the spring of 1877, everywhere, soon after the young had been hatched, they began to dwindle from various causes already known to us, until but a very small per cent. of what had hatched remained; how these from weakness were unable to migrate in every instance, and where they succeeded and deposited their eggs, how accident after accident befell them, until they were almost entirely obliterated from the face of the earth. I need not enter upon a discussion of these facts that are already known and that have been pretty widely circulated by the Entomological Commission, of which my worthy chief was head. Aside from this, however, I consider it my duty to give all the information possible in reference to its probable appearance and movements in the future, in order that the farmers and horticulturists of our country in general may know how to plant accordingly.

For a distance of some forty or more miles below McLeod the country along the river retains the characters it has in the vicinity of the above-named place, after which it gradually changes to a high, dry, and almost level plain, the surface of which is covered by a medium growth of short grasses somewhat superior to those of the plains of Western Dakota, but far inferior to those of the prairies of Nebraska, Iowa, Kansas, Minnesota, and Eastern Dakota.

The river bottoms become less wide, the hills higher, and timber less abundant. At long intervals deep coulees extend back from the river into the plains and form almost impassable barriers to wagon or cart travel. These coulees in the spring-time are the beds of small streams that are formed by melting snows. Some of them support a meager growth of choke cherry and Buffalo berry bushes on their sheltered sides, but otherwise there is but little trace of vegetation which bears the semblance of shrub or tree away from the river banks.

After passing the mouth of the Old Man's or Arrow River and entering the Belly River, there begin to be traces of coal in the high and almost vertical cliffs that are now quite frequent on both sides of the river. These cliffs, for the most part, are composed of clayey soil highly impregnated with the various salts of soda and potash, and occasionally a magnesia spring is passed. But very little if any vegetation grows on these steeply-worn hills, and they look quite desolate. By the time the St. Mary's River is passed, these cliffs contain some rocks of a more substantial character; the coal signs have developed into coal seams, and now and then a stratum or perhaps a series of strata is passed that contain numerous fossils of various kinds. All these characters just noticed continue to become more and more decided from time to time until they finally culminate in a narrow gorge, like a valley,

with steep rocky and clayey walls in which are to be seen numerous signs of spontaneous combustion among the coal seams.

This condition of affairs is to be met with in the neighborhood of the mouth of the Bow River. Now all traces of tree and bush have faded from the scene; all around is a black, barren wilderness, rendered more desolate at night by the shrill howlings of the gaunt and hungry coyotes that linger about our camping ground. The river now has widened out to be quite a large stream, in most parts navigable to fair-sized steamers; and its banks are turreted and grooved into fantastic forms, reminding one of the great bad-lands of the Missouri River region. All along, wherever sufficient shelter is afforded, and also at many places where there is no shelter of any kind, on the cliffs are stuck to the rocks and stowed away in nooks and crevices countless numbers of he little mud nests of the cliff swallows (*Petrochelidon lunifrons*). These remind one of a collection of inverted funnels. All their occupants had already flown away to more genial climes, or "dived down into the mud," not to appear again until next spring, as some superstitious individuals would try to make us believe. Among these are also to be seen the nests of two other swallows, viz., the Bank Swallow (*Cotyle riparia*) and the Barn Swallow (*Hirundo horreorum*). These two species were still lingering about in small numbers. Their nests were not nearly as numerous as were those of the former species. All these swallows lived upon insects of various kinds, and judging from the great amount of excrement upon the rocks beneath the nests, they must have destroyed an incalculable number of them. Very likely half of these were locusts of the various species found in this country. This being the case I do not wonder at the scarcity of insect life along this river and in the country for many miles on either side. Besides swallows, great numbers of various kinds of hawks and falcons had their rudely-constructed eyries perched upon rocks, cliffs, and often on side-hills, while every tree of sufficient size contained from one to three or four of these rude structures.

The country lying back from the river on each side is high, dry, and generally level, and varies but little in its general appearance and character for hundreds of miles from west to east, and two to three hundred miles from north to south. Of course, at several points the general level of these great plains has been disturbed by internal forces, and small mountain groups are the result. Numerous small depressions have also been made throughout the country, too, and these are now occupied by alkaline lakes.

Soon after leaving Fort McLeod the country to the northward was all burnt over. This fire extended from Willow Creek to the Little Bow River. On the south side fires had already swept over all the country from the mouth of the St. Mary's to far below the Little Bow. Again, from the Bow to the Red Deer all was burnt off, as well as a greater portion of the country lying east of the mouth of Seven Per-

sons' River and between that and Fort Walsh. Between Fort Walsh and Old Wives' Lake, too, more than half of the country was burnt. At several points along the river where we camped, I made small collections of various species of locusts and other insects. These were found close to the river on little spots somewhat isolated from the other country, and hence were not reached by fires.

From the scarcity of all classes of insect life in these burnt districts, it would appear that the fires destroy the insects in great numbers. But whether this is done in time to prevent the depositing of eggs, or not, I did not learn. I found many charred bodies of locusts that apparently belonged to several species. Some of these contained eggs, and others were still in coition. They were too much disfigured, in most cases, to tell with certainty the species to which they belonged.

During the journey down the river, short excursions were made back into the country at six different points. These were from three to six miles in length, but disclosed nothing in reference to the Rocky Mountain locust, more than to give us an idea of the surface of the country. We were thus enabled to make comparisons, from time to time, of the country now being traversed with that already passed over. Although the general features of the entire country were those heretofore mentioned, we could discern a slight variation, from time to time, both in the vegetation and soil. The farther down we went the more sage-brush was seen. This sage is not the same as the sages of Wyoming and Utah, but more nearly resembles *Artemisia ludoviciana*. It grows more abundantly on sandy soil comparatively free from rocks. Several other Artemisias are also occasionally met with, but these are small and inconspicuous.

At a point about twelve miles above the mouth of Bow River, on the south side, the upland is quite sandy, and much pawed over by buffalo. Of course this has been done several years ago, as there are but few of those animals left in the country at the present time. At various other points also there is a very similar soil, one of these being several miles to the northward of Medicine Hat, or the crossing of the Saskatchewan at the mouth of Seven Persons' River. At this latter locality we hired a man with his team to take us across country to the terminus of the Canadian Pacific Railroad. Our route lay through the Cypress Hills to Fort Walsh, and thence eastward for some forty-odd miles, after which we turned to the northeast and traveled in that direction until we struck the surveyed line of the Canadian Pacific Railroad, near Rush Lake, after which we again turned east.

In making this journey a great diversity of country was passed over and a distance of about 300 miles traveled. During the first day we followed up the course of a small coulee that extends back from the Saskatchewan to the Cypress Hills, part of the time keeping the high land and at other times choosing the valley. Here also the surface was bared of its vegetation, save in a few isolated spots, by prairie

fires. At several points we made small collections of the locusts, as well as of other insects which were to be found during the short interval allotted to feeding the horses. These differed in no respect from those already collected while coming down the river.

Our second day's journey was over a portion of country much like that in the neighborhood of our camp on Mill Creek west of Fort McLeod, as a great portion of it was among the northern foot-hills of the Cypress Hills. Here the vegetation was ranker, and at many points the grasses sufficiently long and thick for good hay. Trees of a few varieties somewhat common, but not numerous, and fine streams of good water were the attractive features of this portion of Her Majesty's domain, and distinguish it from all the remainder of these great and lonely plains through which we had been traveling for the past three weeks. This range of hills is a kind of an oasis in the desert, so to speak. The Cypress Mountains—or, more properly speaking, the Cypress Hills—are not very extensive, being but about 60 miles from east to west and half that distance from north to south. The country comprised in them is very rough in parts, and in others quite level, though elevated, the summit being a plateau. This is bounded by a timbered belt to the west and north, with an occasional grove on the east. From this elevated plateau, and particularly from the timbered portions, numerous small streams of good water run off to the surrounding and lower country, where it is for the most part evaporated in small lakes and ponds. These streams have all worn for themselves deep cañons, or what in this western country are termed coulees, thus making travel very difficult in certain directions, and particularly so by the route we passed. It is useless for me to go over all this country, piece by piece, as it differs but little in its general characters from that already partially described in the foregoing pages. Suffice it to say that the greater part of it is admirably adapted to the breeding of *C. spretus* and a few allied forms of locusts.

After leaving the Cypress Hills behind, we crossed a vast expanse of nearly level prairie, well grassed, with a loose, sandy, clay soil, well impregnated with various alkalies. This section, also, is admirably fitted for the rearing of locust swarms. In fact the entire country betwen the Rockies on the west and the Souris River on the east is one vast hot-bed, calculated to produce the largest and healthiest swarms in America. These breeding grounds must not be understood to lie altogether within Canadian territory, for such is not the case. We, too, in the United States, have a continuation of these cradles of the ravaging pest in the features of western Dakota, of Montana, Wyoming, Idaho, Utah, Nevada, Oregon, and a small portion of southeastern Washington Territory, as well as in some of Nebraska, Kansas, Colorado, Texas, and New Mexico. But with us these permanent breeding localities are more separated by high mountain ranges, timber belts, and bad-lands, as well as desert and sage-brush regions.

The question now arises, Has there been any plausible and practical means discovered during any of these extended tours by which the locusts can be exterminated? My answer to this, if direct, is *no;* if indirect, *yes*. In the first place we are to make an answer in accordance with the definition of the word *exterminated*. As I understand it, it signifies blot out, and that would require every individual insect o this species to be killed, which would be an utter impossibility. But, by various methods already described in the annual reports of this Commission created by Congress, their numbers could be and will be so killed off from time to time as to bring them under the control of their natural enemies.

During our trip this summer we saw a few locusts of the migratory species at Bismarck, Dak., at Fort Buford, and two or three specimens at intervals afterwards, but nowhere were they as numerous as most species of the "natives." Locusts were also seen in small numbers by Prof. C. A. White while in the vicinity of Glendive, Mont. Professor Aughey also saw a few at several points, and Mr. E. R. Dodge reports a *few* as having been seen in Colorado. Others were reported as having hatched this spring among the sand hills between the Niobrara and Loup Rivers. In none of these cases, however, were they sufficiently numerous to cause fear of an invasion for the following summer.

EXPERIMENTS ON CHINCH BUGS.

By Prof. S. A. Forbes.

MEMORANDA OF EXPERIMENTS RELATING TO USE OF KEROSENE EMULSIONS ON CHINCH BUGS.

Solutions with which dilutions were made.—(1) Soap suds, 1 pound soap to 10 gallons water; (2) soap suds, 1 pound soap to 20 gallons water; (3) potash, 1 pound to 50 gallons water.

EMULSIONS AS DILUTED.

	Per cent. of kerosene.
A. 2 parts kerosene, 1 part milk, 45 parts water.......... about	4
B. 1 part kerosene, 1 part milk, 18 parts water	5
C. 1 part kerosene, 1 part milk, 18 parts solution 1	5
D. 1 part kerosene, 1 part milk, 38 parts solution 2	2½
E. 1 part kerosene, 1 part milk, 38 parts water	2½
F. 1 part kerosene, 1 part milk, 38 parts solution 3	2½
G. 1 part kerosene, 1 part milk, 30 parts solution 2.......... about	3

On the 22d of July I transplanted several hills of corns to the laboratory, placing them in boxes about a foot and a half wide by two feet in length. The corn was from two to three feet in height at this time. Each hill was infested with several hundred chinch bugs, which were of various sizes, below the pupa stage. All the corn was watered once immediately after transplanting, and bore the removal well. It was kept under shelter, but in the well-lighted dome of the building, and fully exposed to the air.

Experiment 1, *July* 22, 9 *p. m.*—Applied to a single hill from half a pint to a pint of emulsion A, throwing it with a small syringe upon the bases of the stalks and surfaces of the ground. For a check upon this experiment, I applied water to another hill in the same quantity and in the same way. July 23, 9 a. m., the bugs on the first hill were still alive, but torpid. July 24, at 11 a. m., about one-fifth of the bugs were completely dead; the others were still alive, but most of them torpid. July 26, 3 p. m., thirty of the bugs were alive and back upon the stalks, apparently uninjured, but all the remainder were dead. July 27, 10 a. m., the hill was in the same condition. Treated again with emulsion B, on the 28th, when all the bugs were killed. Those on the hill to which water was applied were not injured in the least, but all were back again upon the stalks in twenty-four hours.

Experiment 2, *July* 24, 4.30 *p. m.*—Applied to another hill in the laboratory one-half pint of emulsion B. July 25, 10 a. m., four fifths of the bugs were dead. Those alive were almost entirely under clods, and some here were also dead. On the 26th and 27th about forty bugs were found to be alive, and all the remainder dead. On a hill treated with water at the same time no effect was produced.

Experiment 3, *July* 25, 3.30 *p. m.*—Applied seven pints of emulsion B to eighteen hills of corn in the field, selecting those worst affected. The weather was very hot and dry. The solution was applied with a hand force-pump. The hills treated were surrounded by fence boards placed on edge and daubed plentifully with fresh coal tar, to prevent interference from outside. On the 26th, at 11.30 a. m., about four-fifths of the bugs were entirely dead. At 5 p. m. of the 27th the situation was unchanged.

Experiment 4, *July* 28, 11 *a. m.*—A hill of corn in the laboratory was treated with half a pint of emulsion C. At 5 p. m. the bugs were all dead but about a dozen. On the 29th, at 11 a. m., could find but four that showed signs of life. On the 31st of July fourteen bugs were alive and at work on the stalks.

Experiment 5, *July* 28, 7 *p. m.*—I treated thirteen hills of corn in the field with emulsion C, applying half a pint to each hill. The following night was cloudy but dry. On the 29th, at 9 a. m., nine-tenths of the bugs were dead, and those alive were nearly all under clods. On the 29th, at 5 p. m., from 90 to 95 per cent. were dead, piled up in masses everywhere upon the corn and ground. August 2, 5 p. m., on comparison of these hills with others adjacent, I found that the bugs upon the latter were about five times as numerous as those upon the hills which had been treated. From this and the preceding experiments I infer that the bugs were still hatching.

Experiment 6.—I spread upon a glass slide as thin a layer of emulsion D as I could apply with a camel's hair brush, and allowed five bugs to crawl over it. Four, whose bodies were reached by the fluid, died in an hour, but the one remaining was unaffected.

Experiment 7, *August* 1, 12 *m.*—Applied half a pint of emulsion E to a hill in the laboratory. August 2, 8 a. m., from one-half to two-thirds of the bugs were dead, and those alive were collected upon the highest points of ground. August 4, at 8 a. m., probably three-fourths of the bugs were found to be dead.

Experiment 8, *August* 1, 12 *m.*—Applied one-half pint of emulsion D. August 2, 9 a. m., nine-tenths of the bugs were dead. Those alive were nearly all on the ground. This dilution with soap-suds holds much better than that with water.

Experiment 9, *August* 1, 12 *m.*—Applied half a pint of emulsion F. August 2, 8 a. m., one half of the bugs were dead; the others were on the ground and on stalks. On the 4th of August nearly all were dead.

The three above experiments were intended to test the comparative

efficiency of water, soap-suds, and a solution of potash as diluents of the emulsion. The first effects were evidently in favor of soap-suds, showing that this is at least most prompt in its action. The comparison of final effects was interfered with by the fact that about this time the bugs on all the hills commenced to die indiscriminately from some cause not clearly understood.

Experiment 10, *August* 2, 2 *p. m.*—Applied half a pint of emulsion D to the worst hill in the laboratory. August 3, 9.30 a. m., nine-tenths of the bugs were dead; the others were scattered on the ground. August 4, 8 a. m., 95 per cent. of the bugs were dead, and the others still torpid on the ground.

Experiment 11, *August* 2, 5 *p. m.*—Applied one-half pint of emulsion F to a hill in the laboratory. At 10 a. m. on the 3d fully 90 per cent. of the bugs were dead.

Additional experiments, which I have not time to detail, showed that milk is not necessary to the emulsion, which can be made at least as well with soap-suds (1 pound to 10 gallons of water), using equal parts of the oil and suds; that a mere mechanical mixture of the simple oil and water is effective, and does not injure the corn (at least in a ratio of 5 per cent. of the oil to 95 of water); that all these fluids accomplish their purpose when poured on with a sprinkler as well as when applied forcibly in a spray, and that they kill the adult bugs as easily as the young.

S. A. FORBES.

NORMAL, ILL., *August* 22, 1882.

EXTRACTS FROM CORRESPONDENCE.

GRAPTODERA CARINATA INJURING FUCHSIAS.

By this mail I send insects which I have found eating the leaves of fuchsia much in the same way as the potato bug eats the leaves of potato vines. Having never seen anything of the kind before, I would like to know whether they are common or not. They do not seem to eat the leaves of any other plant, so far as I have been able to observe. Hoping that I am not trespassing too much on your valuable time.—[Edwin Lonsdale, Germantown, Pa., September 1, 1882.

REPLY.—Your favor of yesterday and the accompanying box to hand. The insect that troubles your fuchsias is a flea-beetle, *Graptodera carinata* (family *Chrysomelidæ*). You will find a short account of this insect on the inclosed slip from the American Entomologist, Vol. III, p. 200.

THE ARMY WORM AT SARATOGA.

Inclosed please find the best specimen I could find of the worm or caterpillar which destroyed 25 acres of meadow in the town of Saratoga Springs. I would like to know if they are the genuine Army Worm. The worm is about one inch long or longer, black, with two stripes the length of the body. Please have a report sent to me.—[F. D. Curtis, Charlton, N. Y., August 21, 1882.

REPLY.— * * * The worms enclosed in this letter, although badly shriveled and almost unrecognizable, seem without doubt to be genuine Army Worms. The Department is about to publish a special bulletin on this insect, an abstract of which is contained in the forthcoming annual report. The annual report for 1879 also contains a summary of its natural history, and a brief review of the known remedies.

THE ARMY WORM IN LOUISIANA.

In relation to the specimen of the Cut-worm that has done so much damage here, I send you a good collection, which was easy to find. The early Summer Flint that I planted the 9th of July as a trial to see if it would have time to mature in the richest soil of the Red River Valley. The Cut-worms have attacked it since a week, but they are not as numerous as in May and June. These worms attack the corn in the root, and others conceal themselves in the heart of the plant, which it destroys, following to the root. It attacks the cotton when very young—about fifteen days old—which in some places it has entirely destroyed. I hope this will give entire satisfaction.—[W. J. Conder, Marksville, La., August 8, 1882.

[The specimens were genuine Northern Army Worms (*Leucania unipuncta*).]

AGROTIS INERMIS AND HALTICA PALLICORNIS INJURING SMILAX.

Accompanying this I send a worm which I have found eating my smilax. It was first found in day-time feeding, five or six plants being killed before my attention was attracted by its depredations. I noticed about the 3d instant that about 400 plants had all the young leaves and shoots entirely eaten; on looking for a cause I could see

nothing. I took a light, about eight o'clock in the evening, and killed from 20 to 25. The next night about a dozen were killed, and the night following four, and the next, one. After that I could see no signs of any until three days ago. I found one plant eaten in a different part of the bed to where the others were caught. Each night I took out a light, but could not find anything until last night, when the one sent was caught. Every morning I could see where he had been feeding; each day his appetite increased, for as much again more was eaten each night than the last. A neighboring farmer says it is the Cut-worm. The plants of smilax are from 1 to 2 feet high, quite tender and succulent. Our smilax in summer time is infested by an insect very closely resembling the cabbage or turnip fly. Will pyrethrum destroy it?—[Edwin Lonsdale, Germantown, Pa., September 14, 1882.

REPLY.—The Cut-worm accompanying your favor of the 14th instant was a specimen of the Variegated Cut-worm (*Agrotis inermis*), which you will find fully treated in my First Missouri Entomological Report, p. 72. Your remedy of hand-picking will perhaps be the most satisfactory under the circumstances. I should like to see specimens of the fly on the smilax, if you can conveniently send them to me. Pyrethrum will undoubtedly destroy them.

I send by this mail a few of the lively little insects which infest the smilax in the summer time. The cool nights seem to stop their depredations, for they do not bother us much after this date. I have put in a few leaves of smilax for you to see. They do not seem to do the smilax so much damage; only to disfigure it, rendering it unfit for sale. The leaves sent are not nearly so badly marked as they are in June and July. Hoping to hear what he really is, I thank you for your attention to what I have sent before.—[Edwin Lonsdale, Germantown, Pa., September 26, 1882.

REPLY.—Your letter of the 26th September, 1882, and the insects injurious to smilax were duly received. The latter proved to belong to a common little species of flea-beetle known as *Haltica pallicornis* Fabr. They are found on many species of plants, and not infrequently do considerable damage to those cultivated in flower gardens.

SPREAD OF THE CLOVER-LEAF WEEVIL.

Has the report relating to the *Phytonomus punctatus* appeared yet? The beetles appear to be about as destructive and plentiful as last year, *and now are found in all parts of the country about here.*—[L. D. Snook, Barrington, N. Y., September 12, 1882.

THE CORN-MEAL WORM INJURING CONFECTIONERY.

I herewith mail you some samples of moth about which I desire some information. You will find in one box two moths, and two worms which will in time develop into moths. In the other box are three lozenges, which will probably be found on examination to contain worms. Please give me their name, and state if more than one yearly crop is "raised"; also, if in your judgment a heat of 130° F., or thereabouts, applied for a period of eight or nine hours, will certainly kill the eggs. What work will give me the fullest practical information in regard to them? Your kind attention to the above will greatly oblige.—[J. W. Wickersham, New York, September 16, 1882.

REPLY.—The insect which has eaten the lozenges is the corn-meal moth (*Ephestia zeæ* Fitch). It is a very general feeder, and it is not surprising to hear of it in lozenges. In my judgment a heat of 130° F. will kill the insects in every stage, if continued for eight or nine hours, and it will probably be the simplest method of destroying them. There are probably two broods each year in New York, the moths appearing in the spring and early fall. The fullest account of this insect will be found in Dr. Fitch's 2d Report, p. 320, under the name of *Tinea zeæ*.

A SILK-SPINNING MITE.

I write for information upon a very curious occurrence to which my attention was recently directed. Last Wednesday, September 6, my father noticed that one of his large ash trees glistened and sparkled in quite a remarkable manner. Thinking it was the oozing out of sap, which in such quantities would have been fatal to the tree, he proceeded to investigate. Judge of his astonishment when he found it to be the complete covering of the tree with an exceedingly delicate, filmy, compact, cobweb (?). From the ground up on the trunk some 25 feet, and extending out on most of the branches, this web reached. The covering was as complete as if a silken kerchief had been wrapped around the tree-trunk. The author of this gigantic cobweb (?) is a minute, orange-colored mite, or some say spider, with his myriads of sisters, brothers, cousins, and aunts. They were found in large masses along the tree-trunk and in the crotches. Concerning the conditions and surroundings I can only say that the tree stands in close proximity to pines, maples, apple, and evergreen trees. The weather has been, the entire summer, of unprecedented dryness. Three days after its appearance the most severe storm we have had for two months developed. This somewhat tore and washed away the web, but to-day, the seventh after its first discovery, it and the mites are still there. Any information concerning this fellow and his workings which you deem expedient and have the kindness to forward, I shall be most deeply thankful for.—[Geo. W. Mansfield, Melrose Highlands, Mass., September 14, 1882.

REPLY.—Your letter of the 14th September, 1882, is duly received, together with the accompanying specimens, which prove to be a species of red mite, closely allied to the so-called "red spider" (*Tetranychus telarius*), but specifically distinct. The facts which you detail are very interesting, but have been previously observed by Mr. B. P. Mann, now of this Department, and mentioned at the Cincinnati meeting of the A. A. A. S. Should you wish to remove the mites from your tree you will probably find the use of kerosene in emulsion the most satisfactory.

THE ROCKY MOUNTAIN LOCUST.

* * * Thus far we have met but few *C. spretus*, and from present outlooks there is no possibility that we will find any numbers of this insect in this vicinity unless they should drift in from across the range. This, however, is not likely to occur, since at the present time great fires are raging in the localities where they would cross were they to come this way. We have quite a number of specimens which we will carry with us, as they might be destroyed in the mails, the roads are so rough and the care so slack between this point and Benton. Have heard it hinted that there are some locusts in the section about the Columbia and Snake Rivers that are causing some trouble. This may be true. * * * At present I do not think there is any danger of locust visitations east of the Rocky Mountains for 1883, but since leaving civilization, "God's country," as Americans call it up here, we have had no opportunity of reading the papers or hearing the news of the day. * * *—[L. Brüner, Fort McLeod, N. W. T., Canada, September 3, 1882.

AN INSECT ENEMY TO THISTLE.

I send an insect with this note, for name. Its food-plant is the Canada thistle, where it inserts its beak in the stalks. I find them so thickly on some of the plants that they almost cover the stems. But my anxiety to learn its name is on account of the relation it sustains to the ants. I wish to send some notes to the *American Naturalist* about the ants and their behavior toward these creatures, which is more interesting than anything I ever observed among the aphides and ants. If it is undescribed, will you name it and write a description, to be inserted with my notes for the Naturalist? I am still studying ants and spiders, and have some very interesting species of the latter.—[Mary Treat, Franklin Falls, N. H., September 4, 1882.

[The insect sent proved to be *Entilia sinuata* Fabr.]

THE WINGLESS WHEAT ISOSOMA IN WASHINGTON TERRITORY.

I have this day mailed to you for investigation some wheat-straws containing the larva or grub of a fly or something else, hoping to have you make an investigation and give me what it may be. Our crop is short, and has been ever since it has infested the wheat.—[J. A. Starner, Dayton, Columbia County, Wash. Ter., September 2, 1882.

REPLY.—The specimens show the insect to be the wingless "wheat-stalk Isosoma" (*Isosoma tritici* Riley) which has been studied during the past two years from specimens received from Tennessee, Missouri, and Illinois. It is also probably the same insect referred to in the *Pacific Rural Press* of three years ago as infesting wheat in California. I cannot enter into a discussion of the insect here, but will refer Mr. Starner to the article in the annual report of this Department for 1881, which is now in the printer's hands and will be issued before the end of the year.

FUNGUS GROWTH UPON HONEY DEW.

I herewith inclose a specimen of insect production which, at present, very closely resembles sponge. It is made by a multitude of small insects, having a fiber very like cotton, attached to posterior or abdomen. Particles you will observe in specimen. I have been much in the woods and fields, but never saw anything like this before attached to leaves and branches of beech trees. There is quite a quantity of insects and product where this was found. If the matter interests you, I will take pleasure in furnishing specimens and details.—[Rev. J. A. Lyons, Johnson City, Tenn., September 4, 1882.

REPLY—The peculiar sponge-like growth upon the beech twig which you send is a fungus (*Scorias spongiosa* Fries), started originally, without much doubt, upon the honey-like excretions of a colony of woolly plant-lice. The species of the plant-louse cannot be determined with absolute accuracy, as you have sent no winged individuals, but it is in all probability the *Schizoneura imbricator* of Fitch. The specimen is very interesting, as I have never before seen this fungus at such an early stage of its growth.

ELAPHIDION VILLOSUM BORING TWIGS OF WISTARIA.

According to your request I send you to-day the "Wistaria Borers" I have collected and placed in a box, to await further results. I prefer that you should watch their development, for I am away from my office too much for that business. The smallest I have observed are about one-fourth of an inch long, and are found just inside the bark of the dead wood; the channels made by them are filled with "powder-post," and generally leave the center of the twig unless the larva is nearly grown, when it seems to strike for the center, and makes itself a home there preparatory to cutting off the limb, which you will see it does at each end of its "cave." The small larvæ are white, with a large head tipped with black. The large ones are of a honey-yellow color. The segments of the body, which are very marked, seem to serve it well for legs while in its burrow, but it is quite helpless when taken out and placed on the hand or on a table. It will move quickly along its channel when it is partly cut open, but cannot crawl at all when placed on a level surface. When you have reared the perfect form I shall be glad to hear from you in regard to it.—[M. C. Read, Hudson, Ohio, September 29, 1882.

[One of the twigs was opened, and the borer proved to be the larva of a Cerambycid, *Elaphidion villosum*.]

THE AID OF SPIDERS IN THE SPREAD OF SCALE INSECTS.

I have reached the conclusion that spiders play a much more important role in assisting the spread of scale insect than any other insects. From the beginning of my

observations I have noticed that leaves which spiders had folded or webbed together for their nests or lairs almost always proved infested with scale, if infested trees were found in the neighborhood. This I was at first inclined to attribute solely to the protection from enemies and parasites afforded by the web and presence of the spider. No doubt, where the source of infection is near at hand, this may give a sufficient explanation of the observed facts. Lately, however, I have been examining with great care a lot of one and two year old trees which I set out myself last March. The stock from which these trees were taken was to my certain knowledge almost absolutely free from scale insect. At the time of setting, the weather was excessively dry and unfavorable; in consequence of which the trees, 600 in number, were badly checked, and to a great extent lost their tops and nearly all their leaves, so that the present growth is all new, produced during the past summer. Notwithstanding, I find to my surprise, scale insects beginning to appear on a large proportion of the plants. Upon some of them the insects have begun to spread over the branches, and the exact spot where the trouble began is no longer ascertainable. In a strikingly large number of instances I find two or more leaves bound together with silk and occupied by a spider, and the inner surfaces of these leaves completely coated with scale insect, when not a trace of the insect can be found elsewhere upon the tree. Furthermore, this lot of trees occupies a position west and north of the remainder of the grove, in the path of the prevailing [S. E.] winds. The adjoining rows of older trees, on the southeast, are many of them quite badly infested with, for the most part, chaff-scale (*Parlatoria pergandii*), there being usually a relatively small number of long-scale (*Mytilaspis gloverii*) mixed with the other species. As is often the case, the proportions of this mixture of species remains quite constant throughout the infested part of the grove. Now, I find in the newly-infested young grove these two scales mixed in about the same proportions, so that no doubt exists in my mind as to the source of their infection. As to the manner in which it has been accomplished, I submit that if, as many persons think, the young lice are transported bodily by the winds, we would have had a very different distribution from that which exists upon the older trees. The larger and heavier young of the chaff-scale would have been carried to a less distance and in smaller numbers than the long-scale. (There have been no unusual storms or very high winds during the past summer.) Again, in a chance distribution by the wind I can see no reason for any evident connection with spider web shelters such as I have mentioned. Individual scale larvæ do not, as far as I have observed, wander far in search of such protection, and do not need it until the colony becomes sufficiently numerous to attract enemies and parasites. The part played by winds is evidently a secondary one, inasmuch as nearly all the web-inhabiting spiders make use of the wind to carry themselves and their bridges of web from tree to tree, and the spiders transport as passengers upon their bodies the migrating larvæ of the scale insect.—[H. G. Hubbard, Crescent City, Fla., September 22, 1882.

THE SEVENTEEN-YEAR CICADA IN NEW YORK.

I have deferred complying with your request to furnish you with data in regard to the extent of the seventeen-year locusts, in order to obtain all possible information on the subject in this section of the country. My means of obtaing data in this matter are quite limited, and, therefore, I can only furnish you with the following: There are two districts in this county (Yates), the towns of Torrey and Middlesex where these locusts were prevalent in great numbers during a part of June and July. Their extent in Torrey covered an area of about four square miles, and in Middlesex, somewhat less. These towns or localities are situated at some distance from each other, one bordering on Seneca Lake and the other on Canandaigua Lake. Middlesex is situated on the western boundary of the county, and Torrey on the eastern boundary. I am also informed that these insects were prevalent in portions of the counties of Ontario, Livingston, and Wyoming, of western New York. I am not able to learn that they made their appearance in any other parts of the State. They con-

tinued about four weeks in the perfect state, and did considerable damage to orchards by piercing the small branches of the trees to deposit their eggs, and thereby destroying them. How long or far back they have made their periodical visits of seventeen years I am unable to learn, but I find a few aged citizens who have witnessed their advents four times according to the above-mentioned periods. I send you some of the wood they pierced last summer, and you may find that some of the larvæ are still in the wood. The pictorial illustrations of this insect and its various stages of being are exactly in accordance with my observations of it.—[Simon Forshay, Penn Yan, N. Y., October 9, 1882.

ENORMOUS NUMBERS OF BEETLES IN STORED GRAIN.

One of the first business men of Detroit, whose house and barn are all in one structure, is flooded with *Silvanus surinamensis*. Now, a miller comes to me saying that a mill which he has just bought is full of insects. One is of the same family as that mentioned above. The other something else. What are they, please? I send several specimens. The miller has taken all his floors up. I have suggested several things, only two of which are effective, bisulphide of carbon and kerosene. I think the former can be made to do the work. We are going to give it a thorough test. Of course we know the danger. We shall run no risk. Can you give me any hints? Have you known anything like it? The *S. surinamensis* in Detroit were in pints; by putting in the barn a piece of meat any time of day one could gather a pint in short order. They were almost as bad in the house. Please advise me.—[A. J. Cook, Lansing, Mich., November 1, 1882.

REPLY.—The beetles which accompany your letter of the 1st of November, 1882, are *Palorus depressus* Fabr. and *Læmophlœus alternans* Erichs. They are both cosmopolitan insects, like most of the grain-feeders. You ask for suggestions; I can recommend nothing better than the bisulphide of carbon, if artificial heat is not available. In either case I should recommend the building of an air-tight bin to use as a quarantine for all flours in the establishment.

EAST INDIAN COTTON-WORM REMEDY.

* * * "With reference to the remedy for cotton insects, I would state that the natives in upper Burma, where cotton is largely grown for China, use *conjee-water* in a fermented state. This *conjee-water* is obtained by boiling rice, and is daily poured in small quantities into a vessel capable of holding from 8 to 10 gallons. Occasionally a little boiled rice is thrown into the vessel, and if any quantity is taken out for use it is replaced from the cook-house the following day. After fermentation has set in, a little salt and the rind of a squeezed fresh lemon is put in. The natives state they have found this preparation efficacious for not only all insects on the cotton-plant, but for other purposes, for killing those which attack tobacco and cigars."—[C. Lucas, Rangoon, British Burma, E. India, November 2, 1882.

A WATER-PROOF INSECTICIDE.

Your report of November 20 has been received, for which please accept my thanks. I have for the last few years been very much interested in entomology, or that part of it which pertains to insects injurious to vegetation, and I think I have made some experiments which may prove of general use, the results of which I have already sent to our State Agricultural Report. I find in the use of an insecticide that when used in solution the finer the spray the more effective. I also use in the solution a small amount of gum arabic or glue; if glue, I add a small quantity of bichromate of potash; this makes it to a certain extent water-proof, so that it can stand two or three showers of rain. I think this water-proofing the solutions will prove of great advantage.—[William Plumer, Lexington, Mass., January 8, 1883.

THE EFFECT OF FROST UPON SCALE-INSECTS.

Your favor of the 28th of December to hand on Saturday last. I have been carefully examining scale insects to be able to tell you the effects of the frosts on them.

We had frost on the 15th, 16th, 22d, 23d, 25th, 26th, and 30th of November; on the 1st, 2d, 3d, and 4th of December; also on the 8th a frost that hurt the orange trees that had tender growth; again, frost on the 16th, 17th, and 18th; on the 17th we had a regular freeze. I measured ice five-sixteenths inch in thickness formed during the night. This freeze hurt many trees so that they have shed their leaves. During this cold weather I have kept myself informed of the condition of the insects. After each of the frosts in November I found migratory larvæ, and no signs of damage to the insects or eggs. From my note-book I read: "November 20. Young brood hatching out." "November 25. This morning young larvæ under scales; when disturbed they run about quite lively." "November 30. Migratory larvæ under scales unhurt." "December 4. Five days' consecutive frost; no damage to insects; numerous young just settled; abundance of eggs ready to hatch." "December 8. Young larvæ alive under scales, ready to run when disturbed." "December 14. Four days' consecutive warm weather; abundance of migratory larvæ." "December 19. Three days of consecutive frost; morning of 17th (thermometer + 25° F.) found migratory larvæ running about; eggs are apparently unhurt; some moisture near; some scales appear to be from the inclosed larvæ, but no damage to them is now visible." "December 27. Several days of wet weather followed by the frost, so that the trees were constantly wet; to-day, although cloudy, the trees are dry; some larvæ are dead, but a large majority are unhurt; no eggs showing signs of injury found; migratory larvæ seen; the young recently settled broods did not appear to be any more hurt than the old ones." "December 30. Wet and cold for several days past; at noon to-day clearer and warm; no migratory larvæ out; many eggs ready to hatch; some males seen issuing." "December 31. Clear and warm; found recently-hatched larvæ and parasites; some males winged and out found dead; in some scales the mother is found dead, her eggs unhurt; old females are dead, while young larvæ settled close by them are alive; all the eggs appear to be on the point of hatching."

These observations are principally made on trees near by my house, which are in no way protected from the weather; some neighbors' trees are hurt worse and some less than mine. At some distant places I hear that the trees are much worse hurt by the frosts than they are here. If I have the opportunity I will go to some of these places and examine the coccids. From the notes you will see that if we do not have any more severe cold than we have had the insects will have a very large number to start the year with. The cold appears to have only killed the most exposed coccids; those on the defoliated twigs suffered much more than those on twigs full-leaved, but in no case, on the most exposed parts of defoliated branches, have I found all killed. I have been careful to observe this; it recalled the survival of some on the exposed sides of trees in the storm in September. They evidently have different individual powers of resistance to vicissitudes of the weather.

There has not been any actual stop to reproduction during the fall and winter, and the cold weather has only postponed hatching and maturity. This was shown by the progress made in spreading from twig to twig, but the general periodical broods appear to have been broken up into small periods, governed by the character of the weather.

There has not been the usual activity on the part of parasites, as shown by perforated scales.

The effect of the frost on the coccids here may be summed up as follows: Hatching and development retarded, a small portion of larvæ killed, but not enough to be of service to the tree.—[Jos. Voyle, Gainesville, Fla., January 1, 1883.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 3.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

WITH PLATES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

5135

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., October 10, 1883.

SIR: I have the honor to submit for publication the third Bulletin from this Division, prepared under your instructions.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. GEO. B. LORING,
Commissioner of Agriculture.

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PREFACE.

This Bulletin contains some recent notes on the Army Worm, especially with reference to its food-plants and to its injuries in the cranberry bogs of New Jersey during the summer of 1882, such injury by this insect not having been previously recorded. There are some additional experiments with pyrethrum, with a view of ascertaining its effect on different insects, and some notes on insects injurious to forest trees. All these notes were prepared for the Annual Report, but were necessarily excluded for want of space.

A report by Dr. E. H. Anderson of observations on the Cotton Worm the present summer in Southern Texas will prove interesting, as showing what is being done in that section, and as illustrative of the persistence of false theories long after they have been exploded. In his correspondence and earlier reports Dr. Anderson has always held to the view that the pupa of Aletia hibernates, and he has given in this report the testimony of several planters to that effect. We publish his report as it was written, as this is our rule in such cases, but we wish the reader to remember that the hibernation of the chrysalis has been definitely disproven, and that it is now an established fact that hibernation takes place in the moth state, and that the pupæ which fail to give forth the moth before severe frost invariably perish.

The machine described and illustrated in our last Annual Report for spraying cotton from below had been perfected to a large extent without accurate field test of its practical working. We very much desired, therefore, to learn whether any improvements could be made in its several parts or what faults it possessed as a working machine, and as soon as news came that the worms had begun to work around Selma, Ala., Dr. Barnard was sent down with the instructions which accompany his report. The advantages of the machine, and they are many, have already been set forth in the Annual Report for 1881–'82; but the report of Dr. Barnard would seem to show that considerable modification in the details, especially of attachment, is necessary. Future experience may lead to the abandonment of the attempt to spray cotton from the ground up, on account of the irregularity of the rows in the average cotton-field, and the adoption of lateral or oblique spraying from nozzles that do not drag entirely on the ground, but hang some inches above it. The objection which the average cotton-field offers will not hold so strongly in case of a crop of potatoes, where the plants are much lower and in much more uniformly-spaced rows. The results of Dr. Barnard's further experiments show that the objections to the

stiff connection, for the reasons set forth, may be overcome when in the cotton-field.

The late Dr. James S. Bailey,* of Albany, N. Y., was commissioned some time ago to prepare a full account for publication by the Department of the wood-boring lepidopterous larvæ of the family Cossidæ, as he had given much attention to this group and was familiar with all of the North American species. It was his intention to have prepared such an article, giving particular attention to life-habits. Unfortunately his health from the period of his instructions to his recent death was such that he was unable to fully carry out the plan, and we furnish the report incomplete and falling short of what it would have been had he lived. We publish it as it was written, and do not desire to be held responsible for his views. The principal species discussed, *Cossus centerensis*, was first described by Mr. J. A. Lintner in the *Canadian Entomologist* for July, 1877, where many of the facts were given that were detailed by Dr. Bailey in a later article in the same periodical for January, 1879, and in the report here published.

This Bulletin concludes with a report by Dr. William McMurtrie, professor of chemistry in the Illinois State Industrial University, upon certain measurements and tests made by him at our request to determine the relative fineness and strength of the fibre of samples of raw silk raised at the Department. A noticeable result of these experiments, as may be seen by reference to the accompanying tables, is that the fibre from worms fed exclusively upon Osage orange is shown to be somewhat finer, and, on the average, equal in strength to that obtained from the mulberry-fed individuals. We also give a plate from photographs taken by Dr. McMurtrie, illustrating the dual nature of the fibre.

C. V. R.

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* Dr. Bailey died July 1, 1883.

OBSERVATIONS AND EXPERIMENTS

IN

IN THE PRACTICAL WORK OF THE DIVISION.

FURTHER NOTES ON THE ARMY WORM.

In the last annual report of the Department we published the most important portion of the chapter on the Army Worm in advance from the Third Report of the United States Entomological Commission. In this article we give some additional notes, together with an account of the rather abnormal occurrence of the worms in the summer of 1882 in certain cranberry bogs in New Jersey.

THE ARMY WORM IN 1883.

In spite of the fact that the spring of 1883 was favorable for the development of the Army Worm, its scarcity almost all over the country has been remarkable. In few years within our recollection have there been so few complaints of damage by the worm. In fact, no well authenticated case of injury has come to our notice,* though in the latter part of June it was rumored to be present in force in Eastern Pennsylvania. In the vicinity of Washington, in localities where last year the moths were extremely numerous, but few individuals have been found.

EXPERIMENTS UPON FOOD-PLANTS.

The normal food-plants of the Army Worm are found among the grasses and grains, not a single species of either, so far as known, coming amiss. Wheat and oats seem to be their favorite among the small grains, though rye and barley are also taken with less relish. German millet, corn, and sorghum are eaten by the worms, particularly when young and tender. They were found in 1881 feeding to a greater or less extent on flax in Illinois, although this is mentioned by Fitch as one of the crops which the worms will not touch. They have also been reported to eat onions, peas, beans, and other vegetables, though probably only when pressed with hunger. As stated in our Eighth Missouri Report, upon the reliable authority of Mr. B. F. Mills, of Makanda, Ill., they have also been known to eat the leaves of fruit trees. Ordinarily clover is disregarded by the worms, though they occasionally nibble at it. A timothy field is often eaten to the ground, leaving the clover scattered through it standing. In this connection it may be well to

*Since this was written it has been reported as injurious at East Windsor, Conn., during June.

state that on the Department grounds at Washington the newly-hatched worms have been found in a folded clover leaf, feeding thus protected, and under such circumstances as rendered it probable that they had been hatched there.

Mr. Lockwood stated in his report (see last Annual Report of this Department) that even the common rag-weed (*Ambrosia artemisiæfolia*) was eaten clean by the worms, and also that the worms in passing through a strawberry patch devoured both the leaves of the plant and the unripe fruit.

In order to establish upon proper authority the facts concerning what the Army Worm will and will not eat when pushed by hunger, we conducted during the summer of 1881–'82 a series of experiments upon different plants, placing each plant in a separate breeding-cage with a few healthy half-grown larvæ. The results show an unexpected power of accommodation to plants in many families, and no resultant variation in the imagines worth mentioning.

The results are summarized below:

PAPAVERACEÆ.—*Papaver somniferum.* (Garden poppy.)

Of four larvæ all attained full growth and entered the ground. Three moths issued.

CRUCIFERÆ.—*Brassica oleracea.* (Cabbage.)

The four larvæ in this case moved restlessly about for the first day without feeding. The second day they began to feed, and by the fifteenth all had changed to pupa. In this state two died, but the other two issued as moths.

CRUCIFERÆ.—*Raphanus sativus.* (Raddish.)

Of four larvæ two lived to issue as moths; one died in the pupa, and one in the larva state.

MALVACEÆ.—*Gossypium herbaceum.* (Cotton.)

All died after feeding slightly.

VITACEÆ.—*Vitis labrusca.* (Grape.)

All died without feeding.

LEGUMINOSÆ—*Pisum sativum.* (Garden pea.)

Of five larvæ, all fed abundantly; transformed and issued as moths.

LEGUMINOSÆ.—*Phaseolus vulgaris.* (Garden bean.)

All died without touching the leaves.

ROSACEÆ.—*Fragaria virginiensis.* (Strawberry.)

The four larvæ experimented on all fed for from seven to ten days and then died without transforming.

ROSACEÆ.—*Rubus strigosus.* (Raspberry.)

Of eight larvæ, all fed well and all transformed to pupæ; only four, however, issuing as moths.

UMBELLIFERÆ.—*Daucus carota.* (Carrot.)

The four larvæ begun feeding on the second day; all transformed; two died in the pupa state and the other two issued as moths.

UMBELLIFERÆ.—*Pastinaca sativa.* (Parsnip.)

Of four larvæ, one died before transforming, one in the pupa state, and the other two issued as moths.

COMPOSITÆ.—*Lactuca sativa.* (Garden lettuce.)

Of four larvæ, one was destroyed by the others before they commenced to eat; the others all fed to full growth, transformed, and issued as moths.

CHENOPODIACEÆ.—*Beta vulgaris.* (Garden beet.)

Of four larvæ, after feeding slightly, three died after six days; the remaining one fed more extensively, transformed to pupa, and issued as an apparently healthy moth.

LILIACEÆ.—*Allium satirum.* (Onion.)

All fed; two died as larvæ, and the other two completed the round and issued as moths.

CONIFERÆ.—*Abies canadensis.* (Hemlock.)

All died without feeding.

THE ARMY WORM IN THE CRANBERRY BOGS OF NEW JERSEY.

In June, 1882, there appeared on the Rockwood cranberry farm, near Hammonton, N. J., an insect enemy which, according to the reports received from Mr. Rockwood, first destroyed the rushes and afterwards the young cranberry vines, thus doing considerable injury. Specimens sent by Mr. Rockwood proved to be the larvæ of a species of saw-fly, which, however, in captivity refused to feed on the cranberry vines.

The following correspondence on this subject explains itself:

HAMMONTON, ATLANTIC COUNTY, NEW JERSEY,
July 4, 1882.

To the Entomologist, Agricultural Department:

SIR: I send by this mail a box of worms which have done me great damage on a cranberry bog. Some say that they are the Army Worm, but they did not come as an army. They are on several cranberry bogs around, but no one has seen them traveling. They are first found on *the bog*, and are found of all sizes, from ¼ inch long to 1¼ inches, and appear to have been hatched where they are found. The young have only been seen on rushes in the ditches where water stands or was. The old spread over the bog, eating first in preference grass, and then attacking the vines. They eat the new, tender growth. The young are transparent and greenish, the full-grown blackish. The large are active, moving rapidly. When touched they drop off the vines and curl up. They work toward evening and apparently in the night. They were first seen about June 20. We have killed some with Paris green, but they seem to be disappearing, even where no Paris green has been used. We find dead bodies where we have not used the poison; but we still find the young and some old, although not as many as a few days ago. Please tell me what you know about them.

Respectfully,

CHAS. G. ROCKWOOD.

P.S.—We have been unable to find a grown one at the time of day we got those I send with this. They seem to touch nothing but grass and cranberry vines.

DEPARTMENT OF AGRICULTURE,
ENTOMOLOGICAL DIVISION,
July 6, 1882.

Mr. CHAS. G. ROCKWOOD, *Newark, N. J.:*

DEAR SIR: Your favor of the 4th instant, with accompanying box, duly to hand. The worms you send, and which are so destructive to your cranberries, are the larvæ of a saw-fly (family *Tenthredinidæ; order Hymenoptera*) belonging apparently to the genus *Dolerus*. I have found the same larva feeding on Juncus at Saint Louis, but it has not before been reported to attack cranberry plants. The subject is therefore of great interest to me, and you would greatly oblige me by sending on as many of the worms as you are able to find, packed according to the above-printed directions. I would also be thankful for any further observations you could furnish on the habits and development of this pest.

Yours, truly,

C. V. RILEY,
Entomologist.

NEWARK, N. J., *July* 7, 1882.

C. V. RILEY, Esq., *Entomologist, etc.:*

DEAR SIR: Your favor of the 6th received. I have written to my farmer to send you more specimens. We thought when I was there that the worms had nearly done their work; and at noon, when we tried to find them to send you, we could only find the old ones. I had earlier in the day found one old one, before I thought of consulting you. They had been on the land about two weeks, and at one time parts of the bog were black with them. Worms supposed to be the same had been on a neighboring bog two or three years ago, and disappeared about July 1. They have not been seen there either year since, although the owner thought he found their eggs. The same worms (so supposed) have been this year on farms 5 or 6 miles from us. They are also on the cranberry bogs near by us. We are in the pine barrens. The cranberries are surrounded with dikes or dams, so as to be completely covered with water in the winter, from, say, December 1 to May 10, more or less, according to seasons and according to the facilities of each location, each not having equal supply of water. We did not get ours fairly flowed last year till near the end of December. I think the water was off by May 10 or 12, having been let down gradually to addle the eggs of insects. We found on July 4, in searching for full-grown insects, dead bodies all in shape, but which when handled fell to pieces. I have told my farmer if he found others to send them to you.

The cranberry is an evergreen. The worms preferred grass and ate the grass growing among the vines first, and then took only the new this year's tender growth of the vines and the buds for this year's fruit, leaving the vines just as they were before the season's growth began. The old growth was not touched.

On the reeds where we found the young worms we found no evidence of the young worms eating the reeds. In one instance, near the worm, I noticed a little place three-eighths inch long where the reed had been gnawed, and it may have been done by the worm.

Respectfully,

CHAS. G. ROCKWOOD.

P. S.—As to the damage, about three-fourths of the buds for this year on my land have been eaten, and three-fourths of the new growth for next year's bearing. My crop will therefore be cut down three-fourths of the expected yield of 2,000 bushels. The new growth has time yet to grow again and form buds for next year. That you may judge of the importance of this matter, I will say that the loss may be estimated in money at, say, $2,000.

DEPARTMENT OF AGRICULTURE,
ENTOMOLOGICAL DIVISION,
July 7, 1882.

Mr. CHAS. G. ROCKWOOD, *Newark, N. J.:*

DEAR SIR: In regard to the saw-fly you sent me as injurious to cranberries, I will say that in my breeding jars they refuse to eat the cranberry plants. It now occurs to me that you may have possibly overlooked the real authors of the mischief, and that the saw-fly larvæ have merely fallen upon the cranberry plants from some other plant. I beg you now to ascertain whether the larvæ really *feed* on the cranberries. By doing so you will greatly oblige.

Yours, truly,

C. V. RILEY,
Entomologist.

NEWARK, N. J., *July* 10.

C. V. RILEY, Esq., *Entomologist:*

DEAR SIR: Your favor of the 7th instant has been received. There is no doubt that the worm of which I sent you the young did the mischief by eating the vines. I suppose that my farmer happened to put in the box only old cranberry vines. They do not touch the old vines, but eat the young shoots off this year's tender growth, and only after exhausting the supply of grass which grows among the vines. But eating the new growth takes the fruit buds and destroys this year's crop, and takes also the growth which is to bear next year. The worms *undoubtedly* feed upon the vines. They leave upon the ground many leaves, but must consume largely.

When I was there, in spots not reached by the worms the new growth arose solid above the old vines, say, 4 inches, so that nothing else could be seen. On the other side of the ditch would be a patch eaten clean down to the old vines, leaving them as they were when the water was taken off and before new growth has started, and the whole patch 4 or 5 inches lower in solid growth than the untouched patch adjoining, and of different color.

Respectfully,

CHAS. G. ROCKWOOD.

We visited Mr. Rockwood, at Newark, N. J., shortly after the receipt of his last letter, and concluded from further information obtained that the saw-fly larvæ were certainly not the authors of the mischief, but that the Army Worm in all probability did the damage. Yet, as doubt remained, we were anxious to settle the question, and sent Mr. E. A. Schwarz to make examination on the spot. The following is the report of his observations:

SIR: In accordance with your directions I have made a study of the injury done to Mr. Rockwood's cranberries as far as it was possible at the time, the insect that did the damage having disappeared more than six weeks previous to my visit at Hammonton.

The Rockwood cranberry farm is divided into squares, each of about 50 acres, surrounded by high dikes, and intersected by numerous irrigation ditches. Two or three other squares are just being constructed, but are not yet inclosed with dikes. The cranberries being fully formed at the time of my visit, August 1, there was no difficulty in taking in at a glance from the high dikes the extent of the damage done by the insect. It was apparent that the damage was confined to a number of the smaller squares formed by the irrigation ditches. On some of these hardly any berries were to be seen, while other squares adjoining the damaged ones, and only separated from these by the narrow ditch, were not injured at all. On the newly-constructed squares, where there is an abundance of grass, the newly-planted vines had severely suffered.

There is but little grass on the cranberry bogs under cultivation, and it was found that those squares had suffered most on which there was most grass, while on those squares where the cranberry vines had nearly exterminated the grasses very little or no damage at all had been done.

No living specimens of the insect that really did the damage could be found, as was to be expected after the lapse of more than six weeks, the worms having been seen on the bog about June 20; but the following traces thereof were discovered: 1. The ground on the damaged squares was literally strewn with excrement, which, though much decomposed at this time, was unmistakably that of a Lepidopterous larva; 2. Numerous heads of a Noctuid larva were found on the ground, most of them in a badly decomposed state, and but a few among them in fair condition. These heads were so abundant that there could not be the least doubt that they belonged to the destructive larva. The Sarracenias growing in some places in the bog each contained numerous specimens of the decomposed larvæ, but in the course of the examination a few fairly well preserved specimens were found; 3. Of pupæ, or rather empty shells, very few could be found, and it appears that the wet ground had prevented the worms from entering the same, and that they mostly perished above ground without transforming; 4. A number of empty Microgaster cocoons, indistinguishable from those of *M. congregatus.*

I will also remark in this connection that I found two specimens, the only ones I saw, of the saw-fly sent by Mr. Van Hise as the originator of the damage. It was feeding on a species of Scirpus (?) which grows in the irrigation ditches.

The cultivated bog is flooded with water during winter and spring to a depth of several feet, so that no Lepidopterous larvæ can hibernate in it. The uncultivated part is also under water most of the time mentioned, but not so thoroughly as the cultivated portion. Outside of the cranberry lands there is but little graminaceous vegetation in the pine barrens. On the 10th of May the water is drawn off from the bog, an operation which is accomplished in little more than 24 hours. After this the cranberry vines and other vegetation start vigorously, the grasses, one or two species of which grow in thick bunches, being there much fresher than anywhere else in the neighborhood.

From Mr. Rockwood's and Mr. Van Hise's observations there can be no doubt that the larvæ first devoured every blade of grass on the squares where the eggs were deposited and that they afterwards, from mere want of other food, began to attack the cranberry vines. They destroyed only the young vines (*i. e.*, those which should have been bearing this and the next seasons), eating the young, fresh leaves before these had fairly opened. At the time of my visit these young twigs had the appearance of being cut with a knife. Mr. Van Hise further states that he saw the worms appear in great numbers at the edge of the irrigating ditches, a great many of them being in the water and on the rushes growing in the ditches. This observation is no doubt correct, as the worms, after passing through one of the squares, finally congregated at the edge of the irrigating ditch and tried to get across, and in doing so got at the rushes, which at the time of my visit still bore evidence of their attack. In general the irrigation ditches were evidently an effectual barrier against the progress of the worms, and whether they succeeded, in one or two instances, in crossing the ditches, or whether the damage on the adjoining squares was caused by worms that hatched on the same, could not be ascertained. At any rate their feeding on the rushes in the water was the reason of the confusion in regard to the saw-fly larvæ. Mr. Van Hise, being instructed to collect specimens of the cranberry enemy at a time when the real depredators had disappeared, naturally did not find any other worms on the rushes than the saw-fly larvæ, which seem to have been very numerous in the beginning of July.

In regard to other injurious insects observed by me on the cranberry bogs, I would mention that at the time of my visit serious damage was done by various species of locusts (*Acridida*), by eating large holes in the berries. Mr. Van Hise resorts to the

following remedy against this pest: In company with another person he drags a long rope across the bog, thus driving away many of the locusts, or at least disturbing them. He says that if this operation were repeated about twice each day the damage would be considerably reduced, as the disturbed locusts do not settle down again to their destructive work until after the lapse of several hours.

No "berry moth" could be observed on Mr. Rockwood's cranberry farm, but considerable damage had been done earlier in the season by another Tortricid larva, which webs together the terminal leaves of the young vines. At the time of my visit not a single living specimen could be found, but I believe that an additional flooding of the bogs would prove a good remedy for this pest.

Respectfully,

E. A. SCHWARZ,
Assistant.

Prof. C. V. RILEY,
U. S. Entomologist.

A careful examination of the more or less irrecognizable specimens found by Mr. Schwarz left little doubt in our minds that the species was the genuine Army Worm, a few of the heads making this decision possible.

It is evident from the facts observed by Mr. Schwarz that the moth had flown from some distance, for the records for that year, as indicated in our last report, show that the insect was quite prevalent throughout that portion of the United States at the time.

REMEDIES.—It follows from the facts obtained that one of the best ways of preventing injury to cranberries in the future is to keep the bog as free as possible from foreign plants, and that the injury may be limited by increasing the number of irrigating ditches and by keeping these free from weeds and other obstructions.

Another method to prevent the recurrence of such invasion of the Army Worm suggest itself: The water is drawn off from the bog on May 10, and the plants not flooded again for the rest of the season. The irrigating ditches are then only kept filled with water in given quantities, according to the character of the season. Now, the water can be drawn off earlier than has hitherto been done, without injury to the plants, and, what is more important in this connection, the water can be let on again without injury to the plants at any time before blooming, *i. e.*, about the last week of June. If the eggs are laid by the moths, as was evidently the case in 1882, during the month of May, it is apparent that a flooding of the bog some time during the month of June (the water to be kept on the bog, say, for about two days) would drown out the worms before they have begun to do the damage.

Wherever an abundant water supply is at command in spring and early summer, and under control, as is the case on the cranberry farms near Hammonton, a repetition of the damage done by the Army Worm could thus easily be avoided. Should the worm appear during or after the blooming season little or nothing could be done against it; but it is probable that at this time the damage done by the worms would be much less serious than earlier in the season, as the leaves on the bearing vines will then be too hard to be very attractive.

EXPERIMENTS WITH PYRETHRUM.

We treated so fully of this insecticide in our annual report for 1881–2 that the value of the powder and the modes of using it are now pretty well understood. The following account of experiments made by Mr. Howard will, however, prove interesting, as we had them instituted in order to show how the different larvæ experimented with were severally affected by it.

1. SPECIAL EXPERIMENT WITH CUTLERS' POWDER NO. 1.

September 20, 11.45 a. m.—Three healthy, half-grown larvæ of the Fall Web-worm (*Hyphantria textor*) placed in small glass tumbler, and a very small quantity of Cutlers' No. 1 puffed on the anterior abdominal segments of each; tumbler covered with glass slip.

In four minutes one seemed affected; moved the head quickly from one side to the other, arched the back, and made rapid jumping movements as if trying to get rid of the powder. In 6 minutes all were similarly affected. At 7 minutes the one first mentioned was struggling violently and incessantly, jumping and writhing the whole body, now on its back and again on its side; no intervals of rest except momentary in this extremely rapid motion.

In ten minutes became quieter, but was still bending the body in all directions; incessantly writhing like a mammal poisoned with strychnine.

12.2.—Motions have become more spasmodic and jerky, and have lost to certain degree the smoothly writhing character.

12.10.—Motions much slower and consist of a slow writhing of the whole body.

12.18.—Motion still slower; the true legs trembling violently at intervals.

12.28.—The motion of the body has become very slow, but the legs are constantly twitching. The rectum is somewhat everted and the abdominal segments have become somewhat contracted.

12.50.—The body is still more contracted, though still moving slightly, the legs still trembling somewhat.

1.40.—The abdomen is still more contracted, but a slight motion is left, which shows that the final paralysis is that of exhaustion rather than of tetanus.

2.00.—Apparently almost dead; only a slight occasional motion of prolegs and mouth parts, with an occasional twitch of one of the true legs.

3.20.—A very slight motion still perceptible; the bodies have shrunken to very small proportions.

September 21, 9 a. m.—Still a slight motion of legs and mouth parts, and one moves also one of its prolegs.

1.15 p. m.—No change.

3.00.—Still no change.

September 22, 9.30 a. m.—No motion left except a very slight occasional twitching of the anterior prolegs.

2. PARALLEL EXPERIMENT IN OPEN AIR.

September 20, 11.45 a. m.—A larva similar in all respects to the preceding was dusted in the same manner with the same powder, in the same quantity, at the same time.

In 10 minutes it began to show signs of uneasiness. In 13 minutes began to struggle. The spasms increased in violence until 12.50 when they began to subside. There were still strong writhings at 3.30, and the body had only just begun to contract; while the confined worms had reached a similar condition at 12.30.

At 9 a. m., *September* 21, the body had shrunken enormously, but there was still motion of the entire body.

3.30 p. m.—No perceptible change.

September 22, 9.30 a. m.—Dead. This seems strange in view of the fact that the confined larvæ which were strongly influenced by the powder at a much earlier period are still alive.

EXPERIMENTS 3 AND 4.

The following experiments were made with nine samples of powder: 1st, the ordinary powder sold by Cutler Bros. & Co., of Boston, next, five samples labeled Cutler Bros. No. 1, No. 2, No. 3. No. 4, and No. 5, sent to the Department for comparative test; 7th, pyrethrum imported by Lehn & Fink, of New York City, in 1881; 8th, the 1882 importation of the same firm; and, 9th, a powder made from flowers raised by Professor Riley in 1882.

In experiment 3, six young larvæ of *Hyphantria textor*, about one-fourth grown, were placed in each of nine labeled, closed tin boxes (11×8.5×3.5 cm.), and a small quantity of each sample of powder was dusted on the dorsum of the anterior abdominal segments of the worms in each box.

In experiment 4, three half-grown larvæ of the same insect were used in the same boxes and dusted in the same manner. Each worm received, as nearly as could be judged by the eye, the same quantity of the powder.

EXPERIMENT No. 3.

	Cutler Bros.' ordinary.	Cutler Bros.' No. 1.	Cutlers' No. 2.	Cutlers' No. 3.	Cutlers' No. 4.	Cutlers' No. 5.	Lehn & Fink, 1881.	Lehn & Fink, 1882.	Riley.
SEPTEMBER 20.									
(Placed in box at 1.50 p. m.)									
At 2.15 p. m.	All writhing violently.	Still writhing violently, but quieter than preceding.	Still struggling, but feebler even than preceding.	All writhing violently.	All writhing violently.	All writhing violently.	All writhing violently.	All writhing violently.	All writhing violently.
2.45 p. m.	All much quieter.	All much quieter.	All much quieter; more so than preceding.	Much quieter; as much so as preceding.	Much quieter.	Still writhing strongly; appear not so badly affected as preceding.	Still struggling.	One small one has almost ceased struggling. The larger ones are still in incessant motion.	No very marked change; the struggles are not quite so violent.
3.45 p. m.	No appreciable change.	More affected than preceding; scarcely any motion.	Very badly affected; almost motionless, except in limbs.	Condition almost identical with preceding; if anything, slightly less affected.	Still quieter	In about same condition as preceding.	Have become quieter.	Still a slight motion of the whole body.	About the same as preceding; rather more motion.
SEPTEMBER 21.									
9 a. m.	All dead but one, which seems to have entirely recovered.	**All dead**	**All dead**	**All dead**	**All dead**	All dead but one, which shows faint signs of life.	**All dead**	**All dead**	**All dead.**

EXPERIMENT No. 4.

SEPTEMBER 20.									
(Placed in box at 11.15 a. m.) 11.30 a. m.	All in violent convulsions.	All in violent convulsions.	All in violent convulsions.	Not yet convulsed.	Two in violent convulsions; one not yet seized.	Slightly convulsed.	Convulsions beginning; quite strong.	Convulsions not yet begun.	All in violent convulsions.
12.20 p. m.	Two have become quiet and are badly affected; one crawls rapidly, without spasms.	Two have passed through the spasmodic stage; one still struggling violently.	All apparently just passed through violent stage.	All just finished violent stage.	One apparently normal; two still violent.	All finished the violent stage.	One still normal; one still violent; one passed the violent stage.	All finished the violent stage.	All finished the violent stage.
1.25 p. m.	One normal; two more quiet and beginning to contract.	One normal; two more quiet and beginning to contract.	All quiet; one worse than others.	No marked change; quieter.	No change.	Feebler, tho' not markedly so.	No change.	One appears to be recovering; two quieter.	All considerably feebler.
3.20 p.	One normal; one appears as if recovering; one feeble, but still alive.	The normal one taken with spasms; two more contracted and feebler.	No marked change; all much shrunken.	No marked change; all somewhat shrunken.	One normal; two quieter and beginning to contract.	All much feebler and shrunken.	One normal; two shrunken, but still strong.	One almost recovered apparently; two shrunken and very sick.	All shrunken and feeble, but not so much so as preceding.
SEPTEMBER 21.									
9 a. m.	One normal; one slightly moving; **one dead.**	One just alive; **two dead.**	All alive, though feeble.	One strong, recovering; one shrunken and feeble; one almost dead.	One just alive; **two dead.**	**All three dead.**	One still normal; **two dead.**	One very sick; one almost gone; **one dead.**	One very feeble; **two dead.**
1.05 p. m.	No change.	No change.	One just alive; **two dead.**	One recovering; one very feeble; one almost dead.	**All dead.**		The last one taken with convulsions.	One almost gone; **one more dead.**	No change.
3.30 p. m.	No change.	No change.	**All dead.**	One almost gone; **two dead.**			Still struggling.	One still alive.	No change.
SEPTEMBER 22.									
9.30 a. m.	One lively, but starved, not affected; **one more dead.**	**All dead.**		**All dead.**			Still alive, though feeble.	**All dead.**	**All dead.**

EXPERIMENT NO. 5.

September 22.—Twelve larvæ of *Plusia brassicæ* and four of *Pionea rimosalis* were placed in one of the tin boxes and sprinkled in the usual manner with Cutlers' No. 5, the powder which had given the best result in the last experiment.

In 5 minutes the Pionea larvæ were affected, and in 10 minutes the small Plusias; the full-grown Plusias not until 25 minutes. The effects upon all were very marked. The rectum was everted, and large quantities of a greenish liquid were ejected from the mouths of the Plusias.

At 35 minutes two of the largest Plusias still appeared normal. The skin of the Plusias being so delicate the heart beat was watched without much difficulty. In the normal individuals the pulse was found to range, after numerous trials, from 44 per minute to 68, averaging about 56.

The pulse of one of the large worms in its first spasms marked 164, and 8 minutes later it had fallen to 150, and in 15 minutes later still to 140.

In a smaller one, which had passed through the first convulsions and had become feeble, the pulse was almost imperceptible from weakness, and though still very fast (136 per minute) had evidently fallen.

At the expiration of 18 hours the Pioneas were all dead, and 4 of the smaller Plusias were also dead. Two of the Plusias had spun up and the remaining 6 appeared perfectly healthy and normal. The pulse of these last varied from 44 to 64.

September 24.—Three more of the larvæ spun up, and the first two transformed to healthy pupæ.

September 25.—The three larvæ which spun up on the 24th have transformed to healthy pupæ.

September 27.—The remaining larva which recovered from the dosing is still strong and active.

September 28.—This larva has also spun up and transformed to a healthy pupa.

EXPERIMENT NO. 6.—EXPERIMENT WITH CUTLERS' "SPECIAL INSECT POWDER FOR ROACHES AND WATERBUGS."

The base of this powder is Dalmatian pyrethrum, but from the odor it apparently contains some red pepper.

September 22.—A full-grown larva of *Hyphantria textor* was placed in a closed glass jar and thickly dusted with this powder, which stuck to the hairs in masses. It was seized with no convulsions, and September 27, after 120 hours, is still alive, though much shrunken and feeble from starvation. The powder apparently had no effect upon it.

September 22.—Four full-grown cockroaches were placed under an inverted tumbler, and a small quantity of this powder puffed in from an insufflator. In 15 minutes all were taken with spasms, and in an hour

were lying helpless upon the table, although still retaining considerable vitality. In twenty hours they were dead.

EXPERIMENT NO. 7.—EXPERIMENT UPON LARVÆ OF DATANA MINISTRA.

This experiment was conducted in the same manner as Experiment No. 4. Three full-grown larvæ of *Datana ministra* were placed in each of nine tin boxes and sprinkled in the same manner with the same amount of the different poisons. The boxes this time, instead of being covered with their own tight tin covers, were covered with slabs of glass, which, on account of the irregularities in the edges of the boxes, did not fit tightly, and allowed for a pretty free circulation of air. But this perhaps was compensated for by the fact that the covers did not have to be lifted to observe the condition of the larvæ. The fact should be remembered in comparing this experiment with No. 4. The following table shows the result, and it will be noticed that the *Datana* is susceptible in a remarkable degree to the action of the pyrethrum when compared with *Hyphantria* or *Plusia:*

EXPERIMENT No. 7.

	Cutler Bros.' ordinary.	Cutler Bros.' No. 1.	Cutler Bros.' No. 2.	Cutler Bros.' No. 3.	Cutler Bros. No. 4.	Cutler Bros.' No. 5.	Lehn & Fink, 1881.	Lehn & Fink, 1882.	Riley.
SEPTEMBER 28.									
(Placed in box at 10.25 a. m.)									
10.40 a. m	Uneasy; no spasms as yet.	Two in spasms; one uneasy.	Very restless; one in spasms.	All three vomiting; one in spasms.	One only in spasms.	One in spasms; vomiting green liquid copiously.	All restless and trying to eat off the powder.	Same as preceding.	Not yet affected.
10.55	Two in spasms; the other quite normal.	No great change.	All three in spasms.	All three in spasms.	All three in spasms.	One in spasms; the others vomiting.	One in spasms; the others unchanged.	Precisely same as preceding.	One beginning to vomit.
11.50	**One dead**; two still struggling.	**One dead**; one very sick; one still struggling.	**One dead**; the others very sick.	**All three dead,** without contraction.	**One dead,** without contraction; the others quiet.	**One dead;** two contracted much, but still alive.	Two in spasms; one nearly normal.	All three in spasms.	All three in spasms.
1.50	**Two dead**; the last one nearly.	**Two dead**; the last one almost.	The remaining two seem almost gone.	....	**Two dead**; the last one nearly.	**All dead**	All alive, but nearly gone.	All apparently nearly gone.	**One dead;** two just alive.
3.30	No change	No change	No change	....	No change	....	No change	No change	No change.
SEPTEMBER 29.									
9 a. m	No change	No change	No change	....	No change	....	All still alive	**One dead;** two still moving somewhat.	**All dead.**
SEPTEMBER 30.									
9 a. m	**All dead**	**All dead**	No change	....	No change	....	No change	**Two dead.**	
OCTOBER 1.									
9 a. m	....	....	**All dead**	....	**All dead**	....	**All dead**	**All dead.**	

EXPERIMENT NO. 8.

September 28, 10.50 a. m.—Seventeen full-grown larvæ of *Datana ministra* placed in a large breeding-cage open at top, and a small quantity of Cutlers' No. 5 blown in through an insufflator, making an atmosphere of dust.

11 a. m.—Some half dozen are writhing uneasily.

3 p. m.—Four are in convulsions.

September 29, 10 a. m.—Two are practically dead, only a slight motion of the thoracic legs remaining; two more on their backs, and only moving slightly. The rest are evidently somewhat affected, but retain their normal position, and are capable of strong motion.

3.30 p. m.—One dead; five others badly affected.

September 30, 9 a. m.—No change.

October 1, 9 a. m.—Five more dead.

October 2, 9 a. m.—Six more dead. The others appear perfectly normal.

NOTE.—This experiment possesses much interest when compared with experiment 7, as indicating the effects of the powder in a tightly-closed box and in an open cage, the latter approaching open-air conditions.

EXPERIMENT NO. 9.

September 29, 2.30 p. m.—A limb of hawthorn in the open air crowded with the Hawthorn Schizoneura (*Schizoneura lanigera?*) puffed upon copiously with Cutlers' No. 5, so that every individual must have had a dose.

October 1, 9.30 a. m.—Could see no effect whatever. The lice were just as numerous and just as healthy.

NOTES ON FOREST-TREE INSECTS.

By A. S. Packard, Jr., M. D., *Special agent of the Division.*

AFFECTING THE CEDAR OR ARBOR VITÆ.

EUPITHECIA MISERULATA Grote.

Although the moth is very common, occurring all over the Eastern United States, flying about and entering our houses through the summer, the caterpillar is rarely met with, though it is liable to prove locally injurious to cedar hedges and ornamental trees. We have reared the moth from caterpillars found on the low bush juniper (*Juniperus communis*), and descriptions of the larva and chrysalis will be found in Bulletin 7 of the U. S. Entomological Commission, p. 248. The following descriptions were drawn up from a specimen living during the last week of August, the chrysalis appearing September 30 on the cedar in Maine, the moth appearing the following spring, early in May, in confinement:

Larva.—Body slender, the sutures between the segments well marked and stained with yellow. The head small, rounded, not bilobed, and not so wide as the body. Uniformly pale green, exactly concolorous with the leaves of the cedar, on which it feeds. The lateral fleshy ridge of the body is marked with greenish-yellow, forming a prominent, interrupted, greenish-yellow lateral line. Supra-anal plate very short, smooth, obtuse at the apex, the edges marked with greenish-yellow. Anal legs thick and short, not broad; no dorsal warts or tubercles, the body being smooth. Length 12^{mm}.

Pupa.—Green, slender. Length $7–8^{mm}$.

AFFECTING THE FIR, SPRUCE, AND HEMLOCK.

EUPITHECIA LUTEATA Pack.

This is a common caterpillar on evergreen trees, excepting the pine, and is described in Bulletin 7, U. S. Entomological Commission, p. 237. The caterpillar is rather flat, the surface granulated, the body reddish and bearing a remarkable resemblance to a red, dead fir leaf. It turns to a chrysalis late in August and early in September in Maine, and the moth appears the following May and June.

The moth differs from *Eupithecia miserulata* in the much longer, more pointed fore wings. The palpi are also larger, acute, and black. It has four regularly-curved, parallel black lines on both wings; it is also characterized by the broad, clear, flesh-yellow or luteous band situated between the discal dot and the extra-discal line. Expanse of wings 22^{mm}.

AFFECTING THE PINE.

THE PINE CARIPETA.

(*Caripeta angustioraria* Walk.)

This is frequently met upon the white pine (*Pinus strobus*) in August and September throughout the New England States, and as late as the first week in October in Rhode Island. Specimens become full-fed by the 8th of August in Maine, and before entering the chrysalis state spin a whitish web, with minute meshes, not a loose web. On the day following the chrysalis appears, and the moth appears in May and June of the following year. It is one of our most showy geometrid moths.

The larva.—Body rather large and thick, thickest on the segment bearing the first pair of abdominal legs. Head nearly as wide as the prothoracic segment, very slightly angulated on each side of the vertex, mottled with dusky spots or marbled with transverse, parallel waved lines. The prothoracic segment rather small, not angulated in front, provided above with small warts. On each abdominal segment a high, transverse, prominent, smooth ridge, somewhat saddle-shaped and bearing at each end a piliferous wart. On the third and second segments from the end no such ridge, these being replaced by piliferous warts, the two on the penultimate segment being rather high and situated near together. Behind these two tubercles on a transverse wrinkle are two small dark warts, and on a succeeding wrinkle are six warts. On the supra-anal plate are four warts, and on the end, which is obtuse, are four small hair-bearing warts. There are similar hairs on the edge of the anal legs, which have a deep crease parallel to the front edge; the lateral ridge is large and rough and interrupted at the segments. The body elsewhere is variously tuberculated, with hairs arising from the warts. The body in general is pale whitish-gray, with a lilac tint or slate color, variously marbled with dark-brown and sometimes with a decided reddish tint. Length 32^{mm}.

Pupa.—Rather stout. Brown, with an obscure dorsal row of irregular spots forming a nearly continuous line or band; a lateral row of large, obscure spots; second abdominal segment from the end of the legs with two warts beneath. Length 15^{mm}.

The moth.—It differs remarkably from any other species of the family by the rich, opake, velvety, ochreous fore wings, with the three broad silvery lines and large discal dot. The head, antennæ, and thorax are pale ochreous. Fore wings opake, deep ochreous, paler at the base; on the inner fourth is a white line forming a single large and acute angle on the median vein, along which it is prolonged beyond the basal third of the wing, extending out nearly as far as the discal dot, though situated below it. There is a large, irregular, silvery-white discal dot and just beyond a broad silvery line, diffuse on the outside; it curves inward just below the median vein and slightly inward opposite the discal dot. Half-way between this line and the outer edge of the wing is a row of irregular white spots, from which sometimes run whitish streaks to the fringe, which between the white spots is ochreous-brown. The hind wings are pale whitish-ochreous above; beneath, washed with yellow-ochreous upon and on each side of the venules. Expanse of wings 36^{mm} (1.60 inches).

AFFECTING THE OAK.

THE OAK-LEAF CRYPTOLECHIA.

(*Cryptolechia schlagenella* Zeller.)

This is a remarkable insect, both as a caterpillar and moth. It is not uncommon in the larval state on the oak, where we have seen it in Maine

and Rhode Island in September. It feeds between the leaves, drawing them together with silk threads. When about to pupate it turns over a portion of the leaf nearly an inch long, lines the interior of the cell thus made with silk, and the moth appears the following spring. We have compared the moth with a type specimen sent to us by the late Prof. P. C. Zeller several years ago, and now in the museum of the Peabody Academy of Science, Salem, Mass., and it is undoubtedly that species, though the row of blackish dots so distinct in the fresh specimen reared by us is not to be seen in the type specimen; otherwise it agrees exactly with the latter. It is not an uncommon insect, but, so far as known, more curious than destructive, though it may at times disfigure the leaves of valuable shade trees.

The larva.—Head large, broad, and flat—as broad as the prothoracic segment; pale horn or whitish color, surface rough; in front crossed by two dark reddish-brown broad lines which form two large shallow scallops; the front line extends along the sides, including the eyes and the front edge of the clypeus; the other is broader, forming two scallops and crossing the apex of the clypeus. On each side of the head below the front line is a short, nearly straight, brown-black line not reaching as far as the eyes. The median suture of the head is rather deeply impressed; the vertex on each side is a little swollen and marked with eight or nine dark reddish-brown more or less confluent spots. The posterior edge of the head is edged with black-brown. The body is somewhat flattened, pale pea-green, a little paler than the under side of the leaf. Prothoracic segment without a shield, but broad, flat, and green like the rest of the body. On the sides of the three thoracic segments is a dark tubercle tinged with reddish between, forming a lateral thoracic line. No dorsal tubercles, but pale hairs, as long as the body, arise from minute points, which are obscurely indicated. Length, 23^{mm}.

The pupa.—Body very thick and stout; the head broad, and the abdomen short and thick; the end of the body very blunt, the tip broad and obtuse, somewhat tuberculated, not spined. The wings reach to the end of the fifth abdominal segment, and on the under side of the sixth and seventh segments are two dark, ventral, small callosities; the tip is broad, truncated, rough, and dark. Length 10^{mm}; thickness 3.5^{mm}.

The moth.—A very large species for the family to which it belongs. Head with the scales between the antennæ and on the vertex loose and thick, not smooth as in Gelechia. Palpi long and slender, smooth, the third joint very long and slender, over one-half as long as the second. It is so large and the fore wings so broad and oblong, that at first it might be mistaken for a Tortrix.

Body and wings snow-white. Fore wings snow-white with two smoky, twin dots at the base of the wing near the costa; two smoky spots inside of the middle of the wing on the internal edge. Beyond the middle of the wing are five or six indistinct, pearly, smoky spots, the central one apparently forming the discal dot. Two faint, curved, smoky lines parallel with each other and with the outer edge, neither of them reaching the costal edge of the wing, and the inner less than one-half as wide as the outer. On the outer edge of the wing, on the white fringe, is a row of about five conspicuous dark brown spots; the base of the fringe is smoky, forming a faint line. Body, hind wings, abdomen, and legs snow-white; antennæ light brown. On hinder part of the thorax, very distinct when the wings are closed, is a large prominent tuft of broad brown scales, which send off different metallic colors, especially steel-blue. Length of body $9\text{–}10^{mm}$; of fore wing 11^{mm}; expanse of wings 24^{mm}.

FURTHER FACTS REGARDING THE EXTENT OF THE RAVAGES OF THE SPRUCE BUD-WORM IN MAINE.

The following facts regarding the extent of the ravages of this caterpillar on the coast of Maine were gathered during the summer of 1883, and for want of space omitted from the report published in that of the Entomologist of the Department of Agriculture.

The westernmost locality at which the spruce bud-worm was observed was on Peak's and other islands in Portland Harbor, the spruce not extending in any great quantity west of that city. The spruces about Sebago Lake were also destroyed by this worm or a similar caterpillar, in 1878, as we are informed by Rev. Mr. Kellogg, a Mr. Townsend being his authority. Around the shores of Casco Bay and on many of the islands, especially Birch Island, Orr's Island, Jewell's Island, and Great or Harpswell Island, also on Harpswell Neck, Mere Point, Prince's Point, as well as other peninsulas extending into Casco Bay, wherever the spruces and firs grow thickly, extensive areas of these trees were observed; also similar masses of dead spruce were observed along the Maine Central Railroad, from Portland to Brunswick, and thence to Bath; also on the shores of Cathance River, at and near Bowdoinham, Me. Wherever the fiords or narrow bays and reaches extend inland, in Cumberland and Sagadahock, as well as Lincoln Counties, the spruce and fir forests clothing their shores had been invaded by this destructive caterpillar. Wherever the spruces were abundant on the Kennebec River, below Bath, particularly on the eastern side, at and near Parker's Point, and also at and west of Fort Popham, there were extensive patches of dead spruces. Similar but smaller masses of dead spruce were observed along the steamer route from Bath to Boothbay Harbor, at and to the eastward of Southport; none were observed on Mouse or Squirrel Islands. In the course of a journey, at the end of July, from Brunswick along the coast to Eastport, we were able to ascertain the eastern limits of the ravages of this worm. Several clumps of spruces which had just died were seen on the Knox and Lincoln Railroad before reaching the Wiscasset Station. At Waldoboro', southeast from the station, was an extensive area of dead spruces which presented the same characteristic appearance as in Cumberland County, and for two or three miles beyond Waldoboro' there were to be seen large masses of dead spruces and firs. Beyond Warren no dead spruces were to be seen; none were observed about Rockland, Camden, Blue Hill, or the islands of Penobscot Bay; none on Mount Desert, or the islands from Mount Desert to East Machias, nor on the road from East Machias to Lubec, although the predominant growth is spruce. No dead spruces were to be seen about Eastport, nor along the Saint Croix River, to Calais, and none along the railroad from Saint Stephens to Vanceboro' and thence to Bangor. From personal observation and inquiry it is safe for us to report that east of the Penobscot River, in eastern Maine, south of Aroostook County, there are no areas of dead spruce. Returning to

Brunswick from Bangor, the characteristic patches or large clumps of dead spruce and fir were not seen until we reached a point south of Richmond, and near Bowdoinham, on and near tide water on the Cathance River. The general absence of any extensive areas of dead spruces around the Rangeley Lakes and the White Mountains has already been referred to in our report. It thus appears that the injury from this worm has been confined, at least south of Aroostook County, to an area on the coast extending from Portland to Warren, and extending but a few miles inland from the sea or tide-water.

The injury resulting from the attacks of the bud-caterpillar are characteristic, as we have stated, the trees dying in masses or clumps of greater or less extent, as if the moths had spread out from different centers before laying their eggs and the caterpillars, hatching, had eaten the buds and leaves, and caused the trees to locally perish. From all we have learned the past season we are now convinced that the spruce bud-worm (*Tortrix fumiferana*) is the primary cause of the disease on the coast. As remarked to us by the Rev. Elijah Kellogg, of Harpswell, Me., who has observed the habits of these caterpillars more closely than any one else we have met; where the worms have once devoured the buds the tree is doomed. This, as Mr. Kellogg remarked, is due to the fact that there are in the spruce but a few buds, usually two or three at the end of a twig; if the caterpillar destroys these the tree does not reproduce them until the year following. If any one will examine the buds of the spruce and fir they will see that this must be the case. Hence the ease with which the attacks of this caterpillar, when sufficiently abundant, destroy the tree. We have not noticed that the spruce and fir throw out new buds in July and August after such an invasion, the worm disappearing in June. On the other hand, the hackmatack or larch when wholly or partly defoliated by the saw-fly worm (*Nematus*) soon sends out new leaves. By the end of August we have observed such leaves about a quarter of an inch long. In the following spring a larch which has been stripped of its leaves the summer previous will leave out again freely, although the leaves are always considerably, sometimes one-half, shorter. Now, if any one will examine the leaf buds of the larch it will be seen that they are far more numerous than in the spruce and fir or other species of the genus *Abies*, being scattered along the twig at intervals of from a line to half an inch apart. Hence the superior vitality of the larch, at least as regards its power of overcoming or recuperating from the effects of the loss of its leaves in midsummer. Besides this, the bud-worm of the spruce and fir is most active and destructive in June, at the time the tree is putting forth its buds, while the hackmatack, which drops its leaves in the autumn, has become wholly leaved out some weeks before the saw-fly worms appear. For these reasons, while the spruce and fir usually die if most of the leaves and buds are eaten after the first season's attack, the larch may usually survive the loss of leaves for two seasons in succession.

In addition to the facts regarding the great abundance of the bud-worm we may cite information given us by Prof. L. A. Lee, of Bowdoin College, who observed the bud-worms in June, 1880, upon the spruces at Prince's Point, Brunswick, and had no doubt but that they were sufficient to cause the death *en masse* of these trees. In 1883 we visited the locality, and many of the trees had been cut down for fuel.

From Rev. Mr. Kellogg we learned the following interesting facts regarding the appearance of a similar, most probably the same, species of caterpillar, even upon the same farm that was ravaged in 1878, early in this century. According to Capt. James Sinnett and Mr. John Jordan, of Harpswell, the spruces of Harpswell and Orr's Islands were destroyed in 1807. Captain Bishops, whose son made the statement to Mr. Kellogg, cut down the dead spruces on these islands and worked six weeks boiling the sea-water with fuel thus obtained, in order to make salt. This was during the embargo which lead to the war of 1812 with Great Britain. It is interesting to note that the bud-worm in 1878 appeared on the same farm on which the spruces had been destroyed by a worm in 1807, or about eighty years previous.

FURTHER DATA REGARDING THE HACKMATACK OR LARCH WORM.

The following facts were gathered during the summer of 1883 in Maine and New Hampshire, and other points in New England and New York, and are here put on permanent record.

We have already stated in the Entomologist's report that the larch saw-fly (*Nematus erichsonii?*) begins to deposit its eggs at Brunswick about the 20th of June. During a journey to the Rangeley Lakes and the White Mountains this saw-fly was observed depositing its eggs, July 1, at Phillips, where it was observed to be abundant. It was also observed on the 2d at the Mountain View House, Rangeley Lake; also on the larches along the Five-Mile Carry from the Middle Dam to Umbagog. It was also observed depositing eggs in trees at Errol, N. H.; and along the route from Errol to Berlin, N. H., it was observed at work July 4, while a number of dead trees were noticed which had died from the effects of their attacks during the preceding season. We learned that they had been destructive last year in Cambridge, N. H.

Early in July these worms were also observed by us on the European larch in Lawrence, Mass., and they were abundant on the European larch on the grounds of Andrew Nichols, esq., of Danvers, Mass. July 16, the larches along the track of the Eastern Railroad from Saco to Portland were observed to be brown, having been partly defoliated by the Nematus larva; some of the trees were almost entirely stripped.

During the last week in July we went from Brunswick to Rockland, and thence along the coast to Eastport, returning to Brunswick by way of Calais and Bangor. The larch is a very common tree in the eastern portion of Maine, especially along the coast, on the islands, and in the northeastern and northern part of the State. It is comparatively rare west of the Kennebec River. It appears, then, that throughout the State

the larch was this summer partly stripped, and a small proportion of the trees were killed. The growths and forests of larch at this time assumed a peculiar light yellowish-brown appearance, as if a light fire had passed through the trees, scorching them and causing them to change their color. This singular tint was characteristic of the larches wherever we went. We noticed this appearance in the larches from Brunswick to Rockland, at Camden and Blue Hill; also on Deer Isle and adjacent islands; also at and about Southwest and Bar Harbors, and other points on Mount Desert Island and the islands eastward; also at Machiasport; but along the road from this town to Lubec the larches had suffered less than at other points in the eastern part of the State. At Saint Stephens injured larches were observed as well as at Vanceborough and the counties west of Mattawamkeag, thence to Orono and about Bangor, and between that city and Waterville.

From Mr. C. G. Atkins, United States assistant fish commissioner, we learned that the larch worm was abundant, stripping the trees, at Bucksport, and also at Cherryfield, Machias, and New Sharon.

General C. F. Walcott, of Boston, who, in September, 1883, spent several weeks at and about the Forks of the Kennebec, informs us that he noticed numerous dead hackmatacks in masses on Wood stream, which enters Wood pond, which is a part of Moose River. He did not, however, see any dead spruce in this region in clumps or masses, although his guide, an experienced boss lumberman, informed him that a great many spruce trees were dying in that region.

In the Adirondack region, from Scroon Lake to North Elba and about Mount Marcy, the larches were universally attacked by this worm, as we are informed by George Hunt, esq., of Providence, R. I., who made a journey of about 100 miles through this region in July.

REPORT UPON THE COTTON WORM IN SOUTH TEXAS IN THE SPRING AND EARLY SUMMER OF 1883.*

By Dr. E. H. ANDERSON, of Kirkwood, Miss.

KIRKWOOD, MISS., *June* 16, 1883.

SIR: I have the honor herewith to make to you the following report:

Having received on the 30th March my commission from the Department and your instructions to visit Southern Texas to investigate Aletia, especially as to its advent and all circumstances having an influence upon it, as well as to make diligent inquiry as to poisons and machinery for distributing them, I left home on the 2d April and reached Houston, Tex., on Thursday the 5th. I remained there several days, interviewing some of the more prominent citizens, especially those thought to be the best informed upon the worm question.

I soon discovered that these gentlemen were more familiar practically with the insects and machines and remedies for poisoning them than those of my latitude, and in fact were old veterans in the warfare waged by them against the Cotton Worm. Judge J. W. Johnson, now editor and proprietor of the *Houston Post*, was the first whom I chanced to meet. He, however, had not prosecuted the study of Aletia far enough to add any knowledge to its natural history, but had paid considerable attention to machines and poisons. I visited his warehouse

* In obedience to the following instructions:

DEPARTMENT OF AGRICULTURE, *March* 20, 1882.

SIR: I inclose your appointment for three months, beginning April 1. You will at once proceed to Southern Texas and institute a thorough inquiry on the following points: First. The earliest appearance of the Cotton Worm in particular sections, and all attending circumstances as to character of soil, elevation, and other surroundings, such as will throw light on the reason for such first appearance; second, the exact condition of things in Southern Texas in reference to remedies, and the machinery in vogue for applying them.

In reference to this last part of your work I want notes of experience from such practical planters as you may meet—what preferences, in other words, as to remedies applied and means of applying them their experience of the last two or three years has led to. At the close of your work you will please make a full report as to these two phases of the Cotton Worm question for that particular section.

C. V. RILEY,
Entomologist.

Dr. E. H. ANDERSON,
Kirkwood, Miss.

with him and examined his poisons and machines, in both of which he is doing an extensive business. He has a large supply of pure arsenic on hand, as well as a compound poison, manufactured by himself, of which he sells large quantities. He presented me with a large box, which I left in the hands of Dr. Ridley, near Hempstead, to be tried and reported upon, which report will be duly forwarded. Judge Johnson's machine for spraying has been described both in your Bulletin No. 3 and Agricultural Report, 1879. He claims, however, an improvement in the branch-pipes, and has arranged the machine to be worked automatically by the pitman or by the driver. His machine is certainly an admirable one, and at the reduced price of $40 is now being rapidly sold. As the season was too early for its practical application I can say nothing of its operation in the field. I had an interesting interview here with Gen. T. B. Howard. He seems to take a great interest in the discovery of Mr. L. C. White, of Jasper, Jasper County, Texas, who professes to have originated a worm-proof cotton by producing a hybrid from Jamestown weed (*Datura stramonium*). He thinks his experiments with the seed have verified Mr. White's theory. I suggested that as they belonged to two different families of plants I could not understand it, but he still thinks Mr. White has accomplished it, as the seed he gave him produced a plant like cotton, except that it had the odor of Jamestown weed and the worms would not eat it, though they eat other cotton planted side by side with it. Mr. White, I learned, had offered his seed to the Department.

I also interviewed at Houston Dr. R. T. Flewellen, to whom I had been referred as better posted on the subject of Aletia than any one there, or perhaps in Texas, as he had made the insect his study for a number of years, and had published his observations and some interesting facts. He soon convinced me that his method of investigation was careful and thorough, and that he had by experiment arrived at certain facts not stated by others, and which alone could be accounted for upon local and climatic causes. I held several interviews with him, in order to elicit all of his views and methods, and invited him to visit Fort Bend with me, which he did, and we thus had the opportunity of a free exchange of opinions and discussion of the opinions of others. As to hibernation of the chrysalis in Southern Texas, his experiments, he says, leaves no doubt. The life term of the moth he believes to be limited to twelve days, twelve in summer and six in winter, as he could never carry one beyond this. This would be due to climatic influence, admitting it to be so.

While in De Witt County I addressed him a letter requesting an answer to certain interrogatories. His reply reached me at Houston, and from it I copied his remarks on hibernation in a letter to you. He inadvertently made his experiments commence in 1868 and end in 1879, when they were made in less than one year; that is, his chrysalides were put up in the fall and were carried through the following winter and summer. I have sent this to him for revision.

I next went to Virginia Point, to visit Judge William J. Jones, a former correspondent of the Department. My interviews with him were most interesting, and were made exceedingly agreeable by his kind and affable manner. His experience with Aletia has been extensive, and has embraced a number of years, during which he has watched its coming and progress closely, and has contended with it most vigorously and persistently. He is regarded on this subject as high authority, and is the originator of an improved variety of cotton, Texas sea-island.

I questioned him closely in reference to his having observed Aletia larva descend by a web to the earth to pass through chrysalis. Although observing that as a rule the chrysalis is made on the plant, he has nevertheless seen it make the descent and pass into chrysalis on the earth. This would be an exceptional case. Although not using scientific methods in his study of Aletia, he has been a close observer, and has made himself familiar with its habits. He has used lights extensively, and believes strongly in their efficacy. He has also experimented largely with poisons, always with the result of killing the worm, and occasionally killing his cotton likewise. This led to careful experiments, conducted by himself, and to the adoption of the following formula, viz:

To 5 pounds of pure, unadulterated arsenic add 1 pound sal soda; boil in a tin vessel holding 5 gallons of water till the whole is thoroughly dissolved. If dry, one quart of this mixture to be put in 40 gallons of water well strained. This will spray one acre. If showery weather, add an additional pint. This will not cost over 3 cents an acre, and will kill in twelve to fifteen hours.

As this place has suffered from the Cotton Worm in past years, no cotton being planted there this season, it will not be amiss to mention some of its topographical features. Judge Jones's plantation is located on the extreme southeastern point of Galveston County, bounded on the east, south, and west by Galveston Bay, and extending to its margin. It forms, in fact, a peninsula, and is comparatively isolated. The soil is rich, black prairie, abounding in shells and lime. The banana, orange, oleander, and cape jessamine, and other tropical fruits and flowers grow luxuriantly. The Gulf breeze is perpetual. The temperature in winter rarely descends below 32° F. The shrubbery as well as the native larger growth and matted weeds would afford admirable shelter for hibernation. It is Judge Jones's opinion that the insect hibernates here and does not come by immigration. He believes likewise that it hibernates as chrysalis, but offered no facts in support of this theory that could be regarded as conclusive.

The next place visited by me was the plantation of Col. L. A. Ellis, at Walker's Station, Fort Bend County, situated in the Brazos bottoms, 3 miles from the river, having in cultivation 3,000 acres, 1,000 of which was in cotton. The season being a backward one, the cotton was small, and an examination furnished nothing of interest.

As the crops here are annually visited by the worm, which, in seasons favorable for its propagation, does great damage, I noted the topog-

raphy. Oyster Creek, quite a large stream, runs through this plantation from north to south, and has upon its banks a varied growth of native and luxuriant vegetation. Among the trees live-oak, cottonwood, pecan, and hackberry are the most conspicuous. From its serpentine course, forming many densely shaded curves, it would afford at many points admirable protection to insects or animals. The large size of the gin-house and corn-cribs situated near by the creek would also afford the best of winter quarters. Winter temperature and all local circumstances favor the belief that Aletia passes the winter here in some form.

From this point I went on to San Antonio, finding cotton too small for observation; but, as all climatic influences seemed favorable, determined to remain there a short time and await answers to correspondence and then go to the most promising field. While there interviewed General H. T. Bee, among others, and felt quite interested in his account of his cotton experiments in Leon and Durango, Mexico. The appearance upon cotton the first year, two hundred miles from any other cotton, and where cotton had never been planted before, leads to the presumption that the worm was indigenous and had fed upon other vegetation previously. General Bee still seems to think that it is generated by some peculiar condition of the cotton plant, on the evolution theory. All local circumstances here, the mildness of the climate during winter, the profusion of flowers furnishing nectar perpetually, and from the succulent perennial vegetation, it would appear to be the paradise of insects.

One marked feature here is what they call the sea-breeze, which is almost perpetual and only interrupted during the prevalence of a norther, which is always of short duration and scarcely worthy of the name. Without this breeze their climate would be intolerably hot.

Finding no field for observation here I went to De Witt County, where I heard the first bale of cotton always came from. Stopped a day at Cuero to see J. C. Hatton, to whom I had been referred. Found him interested on the subject of the worm and conversant with poisons. He recommends the following, viz:

No. 1. Arsenic 1 ounce; hot water to dissolve; boil until dissolved. For one barrel and one acre.

No. 2. Arsenic 1 ounce; to be dissolved in hot water and put into one barrel of water; London purple 1 pound to be added cold and well stirred in. To be used on one acre.

He also showed me several pumps, made of block tin, but none superior to those exhibited and described in Bulletin No. 3. Told me Mr. J. D. Anderson had requested me to visit him, as he thought he had the worm. On visiting Mr. Anderson's field the first object that attracted my attention was the rattoon sprouts from the stalks of the preceding year. On first examination found the eggs of Aletia much more crowded than usual, and upon footstalk as well as leaf, showing a marked preference for this cotton. Specimens of this were sent you at the time. There were occasional stalks found in the middle of the rows, while the

new crop, then (25th April) 10 inches high, and beginning to form, had single eggs only scattered here and there. The only apparent difference was that the foliage on the sprouts was more bushy. These sprouts, I was informed, appear annually, often as early as January in that locality, invariably in March and April, though I must state that I visited a field planted in cotton the previous year, about 2 miles distant, and at an elevation of 20 or 25 feet above the level of the first-named field, and exposed on all sides, where the stalks had not been plowed up, and all were dead.

This field of Mr. Anderson's is on the Guadalupe River, and strictly bottom prairie, varying from black waxy to light brown, and all extremely fertile. The field extends from the river on the west to the hills on the east, where the land breaks off into upland wooded prairie, of lime and gravelly geological formation. The hill skirting the field has at its base a luxuriant undergrowth, among which may be found many native brilliant flowers, and over which flourishes the live oak with its parasitic moss, the cotton-wood, hackberry, and others native to the clime. The country to the south along the Guadalupe is low and level, while to the southeast it presents rolling wooded prairie. Here the gulf breeze predominates, Indianola on the Gulf being but 27 miles distant, and makes the climate delightful. Here, as reported to you in detail, I found the first brood of Aletia in all its stages, except moth, though knowing the moth to be there by the freshness of the eggs, unless all of that brood had perished. Mr. Anderson informed me that previous to the appearance of the worm a number of the chrysalids had been plowed up, and that this was a matter of annual observation, and he had no doubt that the first brood of worms came from the moths that issued from the chrysalids plowed up in March and April, and that the worms often appeared as early as the 1st of April.

Learning how early the old cotton-stalks often sprouted, the early appearance of the worm, the mildness of their winters, the thermometer never falling below 19° F., the porous and loose character of their soil, and as the boll-worm does not affect their cotton, and could not be mistaken in chrysalis for Aletia, it would seem highly probable that the chrysalis would survive their short winter in that locality. Nevertheless, after the most diligent search I could not procure one, nor could I rely sufficiently upon the accuracy of their knowledge of the chrysalis to accept their statements as conclusive; and if the chrysalis did survive the winter up to the 1st of April, I was there too late, as all had emerged as moths.

I visited other places in the neighborhood, but this serves as a type for all.

Mr. Anderson had constructed under his supervision a machine for spraying, that seemed to me to possess advantages over any other that I have seen, both as to its capacity to spray a larger area in a given time and for cheapness. As he has promised to furnish me a draft I will not attempt a description. I will here copy his recipe for poisons:

Early in the season, when cotton is young and tender, one ounce of arsenic boiled in one gallon of water five minutes and then put in a barrel of cold water will destroy the worms. But in order to make it more efficient, add one-fourth pound London purple, mixed up in cold water. This will go over an acre of land when properly applied. When the cotton is older and the worms more numerous double the poison; no danger of hurting the cotton. The worms are about nine days hatching, and as heavy dews and rains will wash off the poison it must be applied every three days in hatching season. The proper time to commence poisoning is when the millers or moths are depositing their eggs. They can be seen at work after sunset and before sunrise.

I regard as important this gentleman's views, as he is a thoroughly practical man, and has the energy to execute as well as the intelligence to formulate his ideas methodically.

From this point I went to Fort Bend on the Brazos, and remained several days with Colonel Cunningham, adjoining Colonel Ellis's, the two plantations cultivating 2,000 acres of cotton. This was early in May. I inquired for the largest cotton, and on visiting the field found a few worms, specimens of which were sent to you. This was the first brood, and unsuspected until found by me. This field was located near Oyster Creek, and had upon it the decaying trunks of live oak, still covered with moss, and pecans. It was designated as mulatto land, and very rich, lying between Oyster Creek and the Brazos. The general features were such as observed upon Colonel Ellis's plantation adjoining. The mildness of winter temperature here, the many secluded spots, the abundance of native perennial flora, and the almost perpetual southern gulf breeze, as well as the great mass of stubble, rendering the soil extremely porous, would all favor the different theories entertained as to Aletia. While passing through many portions of Southern Texas, of both bald and wooded prairie, now devoted to ranches, I could not but pause to admire the profusion of wild flowers of infinite variety, intermingled with native grasses, giving an additional charm to the landscape, and furnishing food for both insect and animal. Here the moth could find a congenial winter home, if nature has endowed it with such longevity.

Next visited Hempstead. As I have reported to you from that point in detail in my correspondence, will now give a mere synopsis. Found the first brood there on the highest point in the field, where bone phosphates had been used as a fertilizer, and where cotton was then, May 14 forming. This plantation was upland wooded prairie, 3 miles from the Brazos, at an elevation of 30 or 40 feet above river, and about 70 above sea level. The soil may be called sandy loam, and quite fertile. The size of the cotton had much to do with the presence of the worm, but there were, perhaps, other agencies that aided in hastening it there. It was found near an abrupt break on the crest of the hill which had become overgrown with rank vegetation, and which sheltered a portion of the field under its lea. Here either chrysalis or moth would have been protected against the inclemency of winter. Here, likewise, all the surroundings were favorable for the preservation of insect life. It is a coincidence not without significance in my experience that the first

appearance of the worm here, as well as elsewhere, was coincident with plowing while the land was wet and temperature ruling high, thus inducing an abnormal temperature by disturbing natural capillarity. The present temperature, May 15, corresponds with the temperature of Madison County, Mississippi, in August, when worms make their appearance there. I here first tried the experiment of burning molasses placed in a pan over a lamp chimney, placing on the ground another plate containing molasses and coal-oil. First night caught two moths, second night caught ten. Would recommend in all cases, the burning of molasses, as it is my belief that the aroma is more attractive than light.

These were the first moths caught, though lights had often been previously used. Will here remark that every field I visited in Texas was infested with ants, varying from the largest to the smallest size, and differing in color. They are great pests and not only damage stands of cotton by cutting it down, as the cut-worm does, but one species sometimes excavates considerable areas with its subterranean houses, and thereby ruins both corn and cotton. They doubtless, from their predaceous habits, destroy a great many worms, and the farmers say they do.

My next visit was to Columbia, Brazoria County, where I interviewed several of the most intelligent citizens, and visited a field on the Brazos in company with Col. John Adriance, an old and highly intelligent planter. Here I found the worm on cotton near the river bank, specimens of which I sent you, though they had doubtless webbed up before reaching you. This brood was about to pass into chrysalis, as it was at Hempstead, showing it to be about contemporaneous. No new features to be observed here. The opinion prevails that the insect winters here.

I next visited Judge William J. Jones in quest of *Anomis exacta*, but had a fruitless search, as he planted no cotton this season. As the specimen sent to you by him, two years ago, was among a lot of chrysalids, gathered both on the Brazos and at his home place, and as he had never seen the larva of *exacta*, to know it distinctly from Aletia, he would have been unable to identify it.

Next proceeded to Columbus, on the Colorado. The soil here was lighter colored and more sandy than on the Brazos, in fact so loose as to be drifted by the prevailing winds. It nevertheless possesses great fertility. I found cotton here of good size and forming, and soon found the worm. Saw here the same topographical features and physical agencies as elsewhere that seem to influence the life of Aletia.

Went on to San Antonio and saw near Seguin in an upland field near the Guadalupe River some of the largest cotton I met with, but saw there nothing of interest to report.

Would have continued my observations in Southern Texas until the end of June, but as I found the insect wherever I went, as far north even as Hempstead, I determined to return to Mississippi, to watch its incoming there, as that is still an unsettled question.

My conclusion is that the southern belt of Texas, as high as 30° north latitude, offers Aletia a secure winter retreat, and that it there passes through its different stages under the influence of temperature; and although cotton is its preferred food, yet it is capable of being sustained upon other plants, selected by the instinct of the parent moth, until the incoming of cotton.

The fact has been established that it was indigenous and perennial in the Bahamas, and from my observation, and all information gathered in Texas, I think the same rule would apply there.

Finally, regarding yourself as the highest authority upon this subject, as well as all others connected with your Department, I can reconcile your last utterance upon the hibernation of Aletia, as far as facts are concerned, with the theory advocated in this report and deducible from all information gathered in my recent visit to Texas. You say "there is nothing more fully established now than that the moth hibernates principally under the shelter of rank grass in the more heavily timbered portions of the South;" and also that "you had been able to obtain the moths during every month." The only difference is a perpetuation of the cycle of transformation instead of a true hibernation in that latitude.

I have the honor to be, with sentiments of high respect,

Yours, truly,

E. H. ANDERSON.

Prof. C. V. RILEY, *Entomologist.*

EXPERIMENTAL TESTS OF MACHINERY DESIGNED FOR THE DESTRUCTION OF THE COTTON WORM.

Report by W. S. BARNARD, Ph. D.*

U. S. DEPARTMENT OF AGRICULTURE,
ENTOMOLOGICAL DIVISION,
Washington, D. C., August 15, 1883.

SIR: Under your direction I have prepared and hereby submit the following report on the experimental tests made during the last three weeks near Selma, Ala.

Respectfully,

W. S. BARNARD, *Assistant.*

C. V. RILEY, *Entomologist.*

REPORT.

The Cotton Worm machine described in the annual report for 1881–82, and now subjected to field tests, is shown to be suited only for cotton so planted that the rows are spaced apart very equally, since it lacks adaptability to the usual great differences of interspaces between the rows. Unfortunately, nothing very closely approaching ideal straightness of rows or equality of width between them can be detected in the South, even in such fields as are said to be "planted perfectly true."

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* Letter of instruction.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
July 14, 1883.

SIR: You will proceed to Selma, Ala., on the 18th of this month to carry out in detail the verbal instructions which I have given you. These are, chiefly, to take with you or send all the machinery necessary to put together and operate the spraying machine illustrated on Plate IX of our last annual report. You will test this machine thoroughly, in order to settle by experience the numerous points that have not yet had practical field demonstration. Thus, the most satisfactory form of nozzle, whether for London purple, Paris green, or kerosene emulsion, the number of rows it is found best to spray at once, the relative effects of finer or coarser sprays, and particularly the effect of petroleum, etc., etc. Be particular to ascertain the actual cost and actual area covered by a given amount of liquid. You will spend no time in testing other devices or modes of poisoning.

* * * * * * *

Respectfully,

C. V. RILEY,
Entomologist.

Prof. W. S. BARNARD,
Assistant, Entomological Division.

In the more evenly disposed cotton, stiff fork apparatus, made light and shorter, to supply only four rows at each drive, and hung loosely upon hooks instead of eyes, without the ratchet lever elevator, and capable of being easily slid by hand to the left or right, as infringement on row crooks from time to time required, proved susceptible of use with due watchfulness; but the eight-row machine was too heavy to be thus shifted by hand, and being stiff-backed with rigid descending pipes, no eight consecutive rows could be found regular enough to be callipered for much distance by this device. The inflexibility also prevented conformability of the apparatus to inequalities of the ground, an elevation straining hard on one descending pipe, lifting the others from the ground, etc., and the light, flexile, jointed nozzle-arms, being borne upon severely by the stiff pipe system, soon became impaired, whereas they had formerly and have since worked well on the yielding stem-pipes of the adjustable machines which were tested at the time of the Atlanta exposition, as well as in these last experiments. For under-spraying, this old-fashioned, stiff, cross-pipe system is shown to be wrong, as originally foreseen, unless some power can be brought to bear to enforce a system of greater straightness and equality in planting cotton. A considerable amount of the irregularity in rows has been attributed to the "constitutional perversity and crookedness of the nigger," appearing from the bad execution of his instructions. But even if this could be corrected it is not the matter of vital importance, for the planter himself, as well as the field-hand, is guided by a natural principle which will always control and stand against any contrary theoretical or mechanical rule. According to "the strength of the ground," the size of plant it will produce, will the rows run wider or narrower in any particular "cut" or part of a "cut." This accounts for the diverging and meandering rows, for the many "cuts" of a plantation differing among each other in their row-widths as observed everywhere.

As to conveyances for underspraying apparatuses, it was found not desirable to use a wagon or cart of ordinary width (5 feet) in cotton only 3 feet wide or less, because of the much injury done to the plants by the wheels. Most of the cotton in the Carolinas, Georgia, Tennessee, Alabama, and Mississippi comes within these dimensions; hence a shorter special axle for the cart or wagon wheels should generally be employed in any conveyance for the apparatus. But where severely threatened by worms the ordinary wagon or cart will do less damage than the pest in any kind of cotton; and it is on this account that wagons are already used to a considerable extent for transporting poison and broadcast spraying devices in all kinds of fields. Mr. A. T. Jones, near Selma, uses four mules on his heavy spraying machine. But ordinarily the common plantation cart will be found the most suitable vehicle. This or the lumber wagon will straddle rows 4 feet apart or over without injury to the plants except in turning, and that is surprisingly small, being least with the cart. With shafts

placed in the usual position the mule must travel on a row to have the two wheels straddle it properly, and this not practical. I obviated the objection by a pair of rough shafts set to one side, one shaft coming from the center of the cart and the other standing outside of the wheel; thus the mule is held nearly in front of one wheel and midway between a pair of rows. In practice it is shown that the slight side-draft caused by this arrangement amounts to almost nothing. And it should be remembered that it is common in the North to use side shafts on sleighs, buggies, &c. The apparatus is easily pulled by one mule, which should travel preferably in front of the right wheel.

The personal labor required is such that the pumper may also drive and keep an eye on the machine behind. It is most convenient when the stirrer, pump, and barrel are placed near the left side of the cart with the lever or pump-handle standing crosswise. The operator then only looks to the right and the left instead of having to look backward. The mule, accustomed to working in cotton, follows between the rows as a rule without being guided, and the pumper is free to turn him at the ends. In this manner one man can use the apparatus alone without working any harder than he should. Still, it is generally preferable to have a boy attendant to assist at times, and where a larger pump with a very wide system of pipes to supply a large number of rows is engaged it will be well to have two men to take turns at pumping in cases where a pump motor is not provided. With such labor, the adjustable under-spraying machines which I have devised and shall notice below were operated, the best hand being a mulatto who worked for fifty cents a day, which is a common price for cotton-field hands. Thus the labor cost is small, and one or two men with a machine can do much more and better spraying than a large gang does by ordinary methods.

The rapidity depends altogether on the width of the pipe-system, or number and width of rows supplied, or the size of the cotton, of the nozzle-discharges and of the pump, on the velocity or pressure applied, and on the speed of the mule. It may vary with any one of these details. I had only one pump, this rather small, and could not try the effects of different sizes. There was not much diversity in the cotton and it was below medium size. At Selma, I labored under difficulties from bad workmanship, from lack of available mechanics for constructing the devices, on which account there were bad joints in the apparatuses, which leaked some, and which would loosen and at times come apart when high pressure was applied, thus causing stoppages in the work. Under the circumstances the question of time and scope could not be very satisfactorily tested; but as to the very fine small sprays for small cotton the following conclusions result from this experience:

Taking nearly average sized cotton, and the parts of the apparatus of medium capacity, an acre and a half was poisoned in one-half an hour, 24 feet wide being poisoned at a single drive, and the rows were quite short. Twice this rapidity can be attained.

The quantity of liquid and poison used also depends on the various conditions stated as determining the rapidity. The amount of liquid to the acre, as near as could be estimated under the circumstances, ranged from 10 to 40 gallons, according to the size of the spray-discharge and of the cotton. The quantity of poison is in direct proportion thereto, being one-eighth to one-half a pound of London purple, or one-fourth to four-fourths of a pound of Paris green to the acre.

The stirrer-pump device is a most perfect thing for the purpose and gave the greatest satisfaction. This contrivance is described and illustrated in the annual report for 1881–'82 (pl. ix, pp. 159–161). The pump has heavy metallic valves, and its piston-head has no soft packing, so there is nothing about it that can get out of order. Yarn packing is used in the stuffing-box at its top. Being double acting it throws a strong and constant stream. Only one trunnion-eye need be moved, and a single iron wedge, instead of two, is sufficient for setting it. The wedge has on its head a catch whereby it is easily pryed out, and an eye by which it is chained fast to prevent losing it. In place of the wooden stirrer bar formerly employed I have made an iron one having a spring at the middle to clamp snugly in the eye at the bottom of the pump. This will not weaken with age or break. The cord or chain for pulling out the bar is not essential, as by having the end bung-hole of two inches diameter a pair of tongs or pinchers can be inserted to take hold of the end of the stirrer and extract it. The main hose or pipe has a screw union, by which it is easily separable from the pump.

The descending pipes between the rows should have flexion and torsion in their joints or segments or hangings. The ground beneath the cotton-rows is highly ridged, and the mid-furrow between each pair of rows is deep. The ground thus formed operates upon the lower parts of each descending pipe or its appurtenances, when suitably shaped, so as automatically to guide the pipe and its nozzles between the rows, and to follow any crooks therein even when the conveyance is not driven in conformity with such irregularities. This automatical adjusting is allowed to a large extent even when the top of the descending pipe is firmly or non-adjustably attached, provided that the descending pipe be flexile in some part of its course. This was shown in the earlier flexile forked machines which were tested for this Department near the Atlanta exposition. For the object in question the descending pipe may be flexile throughout, but it is more commonly preferable to construct this pipe of stiff segments having one or two flexile joints, or very short hose segments; one at its top, and another at about two-thirds or one-half of the way downward therefrom. It is also generally best to make these flexile segments or joints of three-ply or two-ply hose, and only of such length as to allow them to bend like knee-joints, and to suffer a semi-rotation or semi-torsion. This construction prevents the trailing-fork or other end part from getting turned upside down, or from remaining in wrong

attitude after dragging among or over the plants in turning, and it always tends to spring or throw the nozzles back to such positions that they deliver a properly-directed spray into the plants. Where torsion without bending is desired in these flexile places a rod extending through the interior may be employed somewhat as described for cross-pipes and nozzle-arms in the special report of the United States Entomological Commission that has been prepared. The arrangements and constructions referred to have been carefully tested this season to corroborate the results of previous experience. The principle involved is simple and practical in its operation, having been tested at Atlanta, and again this year at Selma, Ala.

The flexile nozzle-arms of the Y-shaped trailing forks which were originally designed with flexile stems worked satisfactorily thus attached; but when these fork-arms were tested on a stiffly hung pipe, the spring-rod inside soon proved too weak. The strong pendant T-forks with curved or sloping side-arms made stiff proximally, and having 3-ply hose for their distal half or two-thirds, stood severe usage by all methods, since they were made of stronger tubing and had much stouter spring-rods within. The spring-rod in each arm had its distal end soldered in a short piece of tube abutting against the stem of the nozzle. Forks of whatever construction will be guided more by the ridges if the arms extend in a somewhat upward direction before becoming horizontal at the ends beneath the plants, as the median part of the fork can then sink into the mid-furrow and be guided by its sides. Probably nothing better than the pendant Y-forks and T-forks can be devised for spraying upward through the center of the plant. An additional pair of short arms or of nozzles may be used with advantage to discharge from near the median line in divergent direction upward through the tops of the plants. The simplest plan is to join these or the simple eddy chambers directly to the stem-pipe or its extension, low down. Such nozzles may be attached side by side, or in what I call a tandem gang. This is a series of short tubes coupled end to end, each bearing an eddy-chamber discharge. These may be rotated on their axes and so are adjustable to different angles. Those who prefer to underspray the top of the plant and care less for its base will find the tandem arrangement by itself the best device for that purpose for throwing from the ground, though the forks answer as well when elevated, and may also be used beneath the base.

The eddy-chamber nozzles seem the best sprayers available for applying the poison. These nozzles have been tested this season with the discharge-hole of various sizes, from one-sixty-fourth to one-eighth of an inch diameter. The smaller orifices give the finest sprays conceivable. Indeed, with high pressure, the spray vanishes into vapor and steam which does not fall, but rises to seek the clouds. From this the damp particles of poison powder must separate and fall. But with ordinary pressure too fine a spray is not attained.

With the fine strainer on the suction end of the pump, clogging materials in the water are prevented from entering the pipe system or the nozzles. Additional smaller gauze strainers were attached to the ends of the metal tubes in one set of pipes. They keep out dirt, etc., when the pipes are separated, but may not prove of importance. The proper method is to have a completely closed system, with folding joints that never need to be separated, so the whole can be folded into a small compact package for transportation by rail or to the field. Such a system has given great satisfaction by its convenience, as well as by allowing no obstacles to enter the nozzles. In spite of the most perfect precautions clogging will occur at the outset or before high pressure is attained, chiefly from the scales of iron separating from the interior of the pipe as loosened by rusting and jarring. With the finest nozzles (one sixty-fourth inch discharge) these seem to cause no more difficulty than with a standard beveled one-sixteenth inch discharge. The nozzle faces may be removed to let out any obstacles which with low pressure are apt to clog the outlet and stop the internal rotation. But a high pressure should always be used, and when this is once up the outlet may be pricked with a pin, and it will discharge with an almost explosive force, instantly starting an inconceivably rapid internal rotation, which, while sustained with due pressure, will by its centrifugal action prevent any particle from again finding the center of rotation from which the discharge takes place. This is especially true of the smallest nozzles, having an outlet just large enough to admit the insertion of a pin. As previously set forth, the inner edge of the outlet should generally be square or sharp. In the eddy chamber a great hydraulic pressure is generated, so great that by thumb pressure the discharge cannot be stopped. The power therein accumulated under high pressure is sufficient to cut through and disintegrate any obstructing particles or fragments, except those of the hardest kind, which are so heavy as to fly off from the center by their weight and momentum when the velocity of rotation is once up or quickly starts.

The top adjustments of the descending pipes are very important. These tops may be variously hung, combined, or constructed. A knowledge of the irregularities of ordinary cotton fields, such as appear chiefly in crooks of the rows and in variations of width between them, prevents the idea of a stiff, unadjustable attachment of the tops of the pipes, which must travel between and more or less against the rows. Conformity to all inequalities of the ground, its numerous ups and downs, its dead furrows, ditches, stones, and stumps, should likewise be attained. It must also be evident that a large, stiff apparatus is difficult to haul about, as it cannot be taken entire through gates except with much labor. Of course it is possible to disjoint the parts beforehand, and then screw them together tight afterwards when the field is reached. This, however, is hardly practicable. In fact the separating and joining of stiff metal joints by field hands is a failure. Plumber's tools are neces-

sary for this purpose. The field laborer of the South screws up the joint too tight, too loose, or in such form as to spoil the screw-threads. Again, the joints become rusted together and a vise must be engaged. The stiff system also requires that very heavy pipe be used, as the leverage on long pipe arms enables them to suffer great strain, to become broken off easily at the end where the thread for the joint is cut, whereas with flexile joints no leverage power but only *tensile* strain can be brought to bear. In the latter case very light tubing can be employed with economy in material, cost, labor, and salvage of cotton. Moreover, only by such light flexile apparatus can any considerable number of rows be treated at once from beneath. These facts have been substantiated by tests of stiff and of flexile apparatus this season more fully than they were by the Atlanta tests, in which one light machine undersprayed eighteen rows of cotton, a strip twenty yards wide, at a single drive. The tests this year have been not only of stiff connections, but also of the constructions whereby adjustability of the descending pipes is effected automatically and by hand. These have already been noticed above or in the previous reports in so far as they pertain to the stem or body of the pipe or its distal appendages; hence, next in order may be considered more specifically and in natural sequence the construction and arrangements of the tops of these pipes as planned and tested by me:

I. The stiff hanging tubes have been tried, as already set forth, in firm union with a stiff back-pipe or cross-pipe such as appears in many of the patented sprayers, as Johnson's, Daughtrey's, etc., while sufficient objections to this arrangement for underspraying have already been presented. It is the first construction which naturally suggests itself to any plumber or other mechanic, but presents no special adaptation for the purpose, as has been shown this season and previously.

II. The extremest opposite construction to the foregoing is attained by having radiating flexile tubes from the main to the descending pipes, instead of a straight and stiff cross-pipe. By this arrangement the hanging pipes are swung apart or nearer together independently, and set on a cross-bar or on diverging bars, at spaces to suit rows having different courses or widths.

By way of variation the tubes may radiate only for a part of the distance, and for a space run close beside each other along a supporting bar before reaching the descending parts. The parts upon the support are preferably of metal, and slide readily in peculiarly locked hooks, as simple, easily separable attachments, specially devised for this purpose. Where the descending parts have flexibility to some extent they may drag in the cotton in turning, as stated above. It is shown that they thus do no noteworthy harm to the plants; also that they themselves do not suffer injury. This flexile construction is simple, and generally preferable in combination with the flexile connectives between their tops. But should any prefer that the hanging parts be elevated above the plants in turning, this is easily done. For such purpose, and to shorten the lever-

age in lifting, the descending part should preferably have a flexile joint just below midway, to bend like a knee when the lift is made. The upper half of the descending pipe is rigidly continuous with the stiff parallel part, forming therewith a bent angle, while the proximal end of the parallel part is turned backward as a hollow tubular crank, having its handle-end communicating with one of the radiating or slack hose pipes, which allow the stiff parts to be shifted laterally. By swinging the backward crank-shaped part of the pipe over to a forward position, into a catch, the hanging parts of the pipe are swung upward above the plants and sustained there. This season two, three, and four of these crank-ended pipes were tried, combined with the same bar. When the horizontal part of such a pipe is short or not too heavy it will be shifted laterally automatically by the trailing part by the method already noticed; but where the pipe is too heavy or rough to slide easily the hand of the pumper must occasionally be used upon the proximal or crank end to shove the pipe into such position as will suitably adjust the nozzles to the rows.

In the divergent arrangements thus indicated the shifting or lateral adjustability is permitted by opening or shutting the angles between the diverging tubes, and this is, in its operation, in some sense, analogous to taking out and letting out slack in the connecting parts between the nozzles. By a surplus amount of inflection or slack, by joint or other flexibility, in a tube or tubes connecting the tops of any two neighboring pipes, whether right, left, or mesial, in a system, the two can be separated, approximated, or independently adjusted to the extent desired. By this method the stiff pieces sliding on the bar and supporting the pipe-tops can be short, light, and arranged somewhat end to end, joined in tandem order, with intermediate flexile crooks that may be extended or shortened as operated by the automatic action of the trailing branch. These tandem gangs of light, sliding segments for supporting or supplying the tops of the pipes, have stood a satisfactory test in the cotton this season.

Such parts may also be arranged on bars having a slope backward or downward, as on the A-frames, or other kinds of frames, or they can be set in a somewhat zigzag manner on a cross-bar. This use of a slope gives certain advantages, and characterizes some varieties of apparatus closely related to that just noticed. In these, the pulling of the downward pipe, by its gravitation or friction, causes its top piece, which has an inclination to slide on the slope, to travel in a diagonal direction along on the support and across the rows; but working in opposition thereto is a pull-line or cord having one end on a winder near the hand of the pumper. Letting out the line allows the pipe to travel farther along the slope, and winding it up draws the pipe in the opposite direction. Thus any pipe at a distance can be easily shifted and set at a point to suit by letting out or drawing the line. This principle I have executed in three ways: In the first, the supply tube

supports the hung-pipe and slides in eyes situated diagonally with reference to the hung-pipe. In the second, the pipe-top is supplied by a flexile piece of hose, and is supported by a long slide-rod on one or two of its sides, and inserted through loose eyes placed diagonally from the course of traction, as in the foregoing case. In the third instance, the top is similarly supplied by a hose, but is hung by a peculiar locked hook, eye, or loop which glides loosely on a stiffly-set diagonal bar. The simple wooden A-frame answers, and a series of small sloping metal bars of gas-pipe were arranged on a wooden cross-bar. This device worked well. Many kinds of winders would apply, but a simple plan is to wind the small rope or cord around a pair of large eye-screws placed 3 inches apart. The set line can be attached at any point along the sliding parts. Behind the proximal end of the range, through which any pipe-top is to be allowed to slide, the line may pass through a large screw-eye and thence to an extension of the pipe-top above the axis on which it is hung. Then the pipe may be drawn to this place, and by an extra pull its top will be brought down to the eye and the lower parts of the pipe will be tilted upward above the plants for turning, when this feature is desired.

Concerning the use of kerosene upon cotton, the following should be stated: About 10 gallons were applied, half undiluted and half in emulsion variously diluted. The undiluted petroleum destroyed about 10 per cent. of the foilage sprayed by it. The undiluted milk-kerosene emulsion ruined only about 2 per cent., and this diluted injures less and less according to the attenuation, but all treated was injured to at least a slight extent. The sprays were hardly satisfactory, as the tubing would not permit the high pressure necessary for a very fine mist, and the indications are that with the finest spray the strong kerosene and its slightly diluted preparations may possibly yet become used, in proper hands with great caution, upon the crop, but additional experimental tests are needed.

The apparatus taken, with the different machines constructed at Selma and overcoming the objections herein set forth, have been shipped to the Department.

The leading conclusions from the experiments upon the special points in my instructions may be extracted from the above and briefly summarized as follows:

At Selma, I operated the machine taken from the Department and tested the points in question, so far as circumstances permitted. The distinctive feature of the machine, its stiff supporting pipes, unfitted it for the work to be accomplished. As fields could not be found having rows practically of the same regular width as the spaces at which the downward pipes were held stiff by their supporting pipe, that permitted no independent lateral adjustment of the tops of the hanging pipes with reference to each other or to the rows having different or varying widths, this vital impediment at the outset frustrated its use and the obtain-

ment of results dependent thereon. The tests showed that with a pipe-system, without lateral adjustability at the top, very few rows, usually not more than four, can be treated at once. In this small form the whole pipe system can occasionally be moved laterally by hand as the row irregularities require it.

The forks were operated dragging upon the ground, and also set at different heights. The ratchet for vertical adjustment subserved this purpose satisfactorily. Where it is desired to spray the base and interior of the plants from beneath, the nozzle arms must necessarily be carried near or on the ground, and with medium to small cotton this method also sprays the tops sufficiently well, but if the growth be heavy and dense it proves better to set the forks higher for more thoroughly poisoning the tops.

The stirrer pump worked admirably; but a larger pump of the same kind was necessary to treat a greater number of rows, to ascertain how large a number it is possible or advisable to spray at a time. While the large pump was being constructed and shipped the time limited by my orders expired.

Four rows may be set as the number it is most practical to treat at a time with the kind of machine in question.

The springs of the fork-arms should be larger and have a longer bend than in the samples taken, since the unyielding attachment of the stem-pipes to the stiff supporting pipe above throws on the springs much greater strain than occurs in the machines having descending parts hung to operate independently of each other.

Until my time had expired worms were not abundant enough to study the effects on them of the coarser and finer sprays applied, but the coarser spray was more injurious to the foliage with poisons, and still more so with petroleum.

The standard form of eddy-chamber nozzle was used with discharges of different sizes. The smallest discharge holes, of $\frac{1}{64}$ to $\frac{1}{16}$ of an inch diameter, with very high pressure, gave the most satisfactory results.

The "actual cost, and the actual area covered by a given amount of liquid," vary greatly with the width between the rows, the sizes of the sprays and of the plants, with the number of nozzles, with the amount of pressure applied and the volume capacity of the pump, the velocity at which the machine is drawn, etc. On account of the complexity of the question, and especially because of leakage from imperfect pipe-joints and for want of other and larger apparatus, the question could not be solved with any exactness.

ON SOME OF THE NORTH AMERICAN COSSIDÆ, WITH FACTS IN THE LIFE HISTORY OF COSSUS CENTERENSIS Lintner.

By JAMES S. BAILEY, A. M., M. D., Albany, N. Y.

Cossus centerensis (Plate I) was discovered by Dr. Theodore P. Bailey in 1877. For many years previous I had observed that many trees of the *Populus tremuloides* had perished from some cause then unknown. The central shoots of other trees of the same species were dead, and it would only require a few years to finish their destruction. Perforations were found in the trunks of these trees, some of recent date and some overgrown with bark, leaving the cicatrices plainly visible.

In July, 1876, a brittle pupa-case of the Cossus was found projecting from one of the openings, which gave the first clue to the nature of the borer and destroyer of the timber.

On the 10th of June, 1877, a fresh pupa-case was discovered, and on the 14th of the same month the first Cossus was captured, resting upon the same tree trunk. Every season since this capture the Cossus has been taken, but in some years in greater numbers than others.

The Cossus usually comes forth between the setting and rising of the sun, and when the trees are visited daily the protruding pupa-cases left behind by the escaped imagines informs the collector how many of the insects he may expect to find.

Their color similates so closely the color of the bark of the trees that it requires good eyes and very close observation to find the moths. One unaccustomed to collect them might view an infested tree for a long time and not find a Cossus, when several would be discovered by an expert. An uneven protuberance on the bark, or the short stump left of a decayed broken limb are favorite resting places for the insect.

The moth at first is rather sluggish, and can be easily captured. After it has been abroad for some days it is wild and more or less mutilated. This Cossus is not attracted by sugar, as might be expected from its aborted tongue.* The moth seems to belong to the genus *Cossus* Fabr., and not to be congeneric with *Xystus robiniæ*. The head is short, eyes naked, labial palpi small, appressed, scaled. The thorax is thickly scaled, the scales gathered into a ridge behind, and is squarer

* The writer is desirous of producing all the known facts in reference to this insect in this paper; therefore the descriptive parts which have been published before are reproduced.

in front than in *Xystus*, not so elongate or so elevated dorsally. The male antennæ are bipectinate; the lamellæ rather short and ciliate. The female antennæ are serrated. It is allied to the European *Cossus terebra* F., but is a larger insect. It differs from *C. querciperda* Fitch by the absence of any yellow on the male hind wing, and by its darker color and closer reticulations.

In color this species is black and gray. The edges of the thorax and collar are shaded with gray, more noticeable on some specimens than others. The primaries are covered with black reticulations, which are not always identical in their minor details in different specimens, nor sometimes on both wings in the same specimen. Beyond the cell there is a transverse continuous line, broader than the rest, and outwardly bent over median nervules. The brown color is blackish over nearly two-thirds of the primaries from the base, and outwardly gray; hind wings rounded in both sexes, with blackish hairs at base, pale and subpellucid, with short gray fringe, before which there is a narrow blackish edging. The abdomen is blackish. The males are smaller than the females. The smallest male expands about 40^{mm}, the largest female over 60^{mm} (see Plate I, Figs. 10, 11, and 12). While thus far the Centre (N. Y.) locality has proved to be the chief home of this Cossus, it will undoubtedly be found elsewhere wherever the *Populus tremuloides* is found. Several pupa-cases of this species have been found in the corporate limits of Albany. Usually trees of less than 1 foot in diameter are attacked, although in one instance a pupa-case was found in a tree measuring 16 inches in diameter.

It is a very different matter to observe the changes of insect life from the eggs to the imago when feeding upon the foliage of vegetation than where the larvæ have bored deep into a tree trunk and feed upon the ligneous fiber and its circulating fluids. To obtain this information it has been necessary several times each year to cut down trees bearing indications of its ravages, and to dissect them into fragments the size of kindling-wood. The months of October, April, and June were selected as suitable times for such investigations. October 14 we visited a tree for the purpose of obtaining caterpillars, and from a limb 4 feet in length six caterpillars were taken, two of which were occupying cells as seen in the engraving.

April 2 we cut from a tree a limb 3 feet in length, and in it we found seventeen caterpillars of three distinct sizes, indicating a growth for each year. The larger ones were not fully grown. All of them were actively passing through their tunnels in the wet wood, through which the sap was freely flowing. Not any of the caterpillars were occupying pupa-cells at this time. June 12, 1881, we again visited a tree when the insects were emerging. The tree selected was far advanced in decay, from the effects of the tunneling of the larvæ; only about 4 feet of the trunk was alive, with a few lateral branches in foliage, scarcely enough to support its respiration. In the trunk were found fresh pupa-cases, pupæ, and

caterpillars. Again three crops of larvæ were found; the larger ones were inactive and lying in the sap-wood, with their heads close to the bark which was gnawed nearly through to the outer surface. These caterpillars had evidently taken their last position preparatory to their final transformation into pupæ. Pupæ were also found occupying the same position, and when the bark was removed were visible.

The larva taken October 14 from its burrows is 45^{mm} in length, of a pale flesh color. It is a little broader anteriorly. The prothoracic segment is blackish brown above, the dark color edged with a dirty orange shading. The head is mahogany brown, shining, slightly roughened. The mandibles are black, with strong teeth. The surface of the head gives rise here and there to single scattered hairs. The antennæ are three-jointed; the second joint gives rise to a single long hair. The seventh eighth, ninth, and tenth abdominal segments are provided with false feet. The segments are marked with a lateral row of brown dots above the reddish stigmata, and there is a row of similar dots, two to a segment, on each side of the dorsal line. These dots give rise to single pale hairs. The larva moves with freedom either backward or forward. The burrows which it excavates are about 15^{mm} in width and terminate in the pupating cell, which is about 40^{mm} in length, smooth; the extremity towards the opening is closed by a wad of finer and then coarser filings of the wood. The coarser splinters are not detached entirely from the wood, but are split up by the larvæ all around the top of the cell, and project like bristles, appearing somewhat as those wooden toy trees which are made for children, and which are formed by shaving down the wood and leaving the shavings adhering by one end. These splinters make a firm wad. Against them are piled a quantity of finer chips or thin filings, which are loose but pressed together.

The cell (Plate 1, Fig. 7) is about 40^{mm} from the outer bark of the tree, and the chrysalis (Figs. 8 and 9) makes its way to the air through the burrow, by means of its teeth on the segments and the spinose process on the front, by which it forces itself, by stretching and contracting the abdomen, through the wood scrapings which close the cell, until it comes to the end. We have noticed a fine thread of silk proceeding from the spinneret of the larva, although in the cocoon we have found no silk whatever. The cocoon or pupa-cell seems to have been formed by wedging first coarser and then finer strips of the wood together, and seems to be merely a more carefully and smoothly finished enlargement of the original burrow.

A specimen of the pupa which I have examined is about 30^{mm} in length, narrow, brownish black, shining rugose. The clypeus presents a strong, broad, spinous process, supported at base by lateral projections. On the under side it descends into a wide sulcation terminating in a broad projection. The capital appendages are visible, and here and there arise isolated hairs as in the previous stage. The abdominal segments are provided with teeth over the dorsum, decreasing in size to the stigmatal

line. The anal segment is provided with two unequal-sized terminal teeth on each side of the vent. (Plate I, Figs. 8 and 9.)

The chrysalides vary much in size, and some of them are infested with an ichneumon fly, which preys on the caterpillar. A pupa was observed endeavoring to make its way to the surface of the bark, but seemingly unable to extricate itself, when assistance was rendered by enlarging the orifice. It was laid in a paper box for hatching. A few days afterwards many minute ichneumons were observed resting upon the wall near the box. On examination they were found to be escaping through minute holes in the pupa, which would barely admit a No. 3 entomological pin. Fifteen of these perforations were counted in this pupa. I presume that the larva of the Cossus is pursued in its burrows by the parent parasite. If so it is curious that the Cossus pupa is not killed by the parasites until it has worked itself up to the mouth of the tunnel, thus allowing the ichneumon flies to escape outside.

When ready to emerge, the pupa, by means of stout cusps on its abdominal segments, works itself to the end of the opening, and with its pointed head-case the thin portion of bark which has been left by the caterpillar's instinct is severed and removed. It pushes itself through the opening as far as the base of the abdomen, by a sort of rotary motion, which acts in its mode of cutting like a carpenter's center-bit. The thoracic end of the pupa after exposure a short time to the air becomes dry and splits, and the moth escapes, climbing up the bark of the tree, shaking out its wings, until developed. After the moth has escaped the empty pupa-case may still be seen protruding from the entrance of the tunnel. It is not true that *Cossus centerensis* prefers dead wood to burrow in. It is a fact that it is most frequently found in partially decayed trees, for after the larvæ obtain a lodgment by its perforations in diverse directions through the heart and alburnum, admitting air and water, it causes irreparable decay. There are three species of poplar found in the vicinity of Centre,* viz, *grandidentata*, *dilatola*, and *tremuloides*, but as yet *C. centerensis* has only been found in the *Populus tremuloides*.

It is stated by Harris that *C. ligniperda* deposits her eggs on the bark near the root of the tree, which I believe is the habit of most of the borers. It would seem from the following that it is not the invariable mode. In splitting open a tree trunk on June 12 a Cossus was observed to fly from the cleft, which on being captured proved to be a female. It was supposed she had taken possession of a tunnel for the purpose o depositing her eggs. The loose *débris* from the excavations was gathered together, an examination of which revealed Cossus eggs. (Plate I, Figs 1 and 2.) The female was confined in a box; the next morning she had deposited fifty-two eggs; some of them were attached to the sides and others on the bottom of the box. Some of the eggs

*Now called Karner.

were deposited singly and some in confused heaps, and were attached to each other and to the box with a viscid substance.

Another female was captured June 20, and in forty-eight hours after being pinned she had deposited sixty eggs, which varied somewhat in color from the former.

The Cossus after being pinned is very restive, especially while depositing her ova and by the constant motion of the oviposter in endeavoring to extrude the ova. The loose abdominal scales are removed and attached to the eggs by the moist viscid fluid with which they are covered, and which often gives them the appearance of being clothed with scales. A few of the ova collected this season have this appearance, but a strong lens exposes the true condition. *C. centerensis* is not so prolific as some of the other species of *Cossidæ*. *C. robiniæ* Peck and *C. querciperda* Fitch have been known to extrude upwards of three hundred ova. In European species over one thousand ova have been found on dissection. The ruin of whole forests of timber in which these insects revel is doubtless prevented by the destruction of the eggs by ants and birds, the size of the eggs being sufficient to form a tempting morsel. In a state of nature the female Cossus deposits a small number of her ova upon each tree which she visits until her supply is exhausted.

This season the enlarged perforations through the bark show unmistakable evidence that the trees had been recently visited by woodpeckers, which could find little difficulty in procuring an abundance of full-grown larvæ.

C. centerensis is found throughout the region known as the pine barrens, which cover an area of perhaps 12 square miles between Albany and Schenectady. The soil of this region seems especially well adapted to the growth of the timber which it supports.

At the present time no correct observations have been made in reference to the molts of the caterpillars, but information on this subject will soon be obtained from Mr. A. H. Mundt, of Illinois, who has had opportunities of observing, up to the fourth molt, the caterpillars of *C. robiniæ*, which are found in the willows and poplars in his vicinity.

Cossus centerensis appears every year, and from observations and from numerous examinations of the trees by actual sections during the three months of the year enumerated, I am convinced that the caterpillars are not fully matured until the end of the third year, when they arrive at their perfect or winged state. The pupa state is comparatively short, lasting less than a month before the moth appears. From figures 3, 4, and 5 of Plate I we see representations of caterpillars found October 14, which establish the fact beyond dispute, through observations extending over many years, that it requires three full years for the caterpillar to arrive at maturity.

COSSUS ANGREZI Bailey.

(Plate II, Fig. 6.)

We repeat the original description of this species, given in Papilio for June, 1882 (Vol. II, No. 6, p. 93):

COSSUS ANGREZI. n. s. ♀. Head somewhat narrow on the vertex. Collar and head yellowish gray, thorax black; the edges of the tegulæ shaded with yellowish gray. Fore wings with a nearly white ground, shaded with black, and with black reticulations. Hind wings yellowish gray, mottled with blackish outwardly. The fore wings have the costal edge pale, marked with black; the black shading obtains on costa at apical third, and over the whole wing at terminal third, extending obliquely downwards and inwards; there are a series of interspacial longitudinal black streaks before the margin, more or less defined. Fringes whitish, dotted with black opposite the ends of the veins, which latter conversely are whitish. Thorax shaded with yellowish gray behind. Abdomen dark gray. Beneath the wings repeat the markings very distinctly, owing to the strong contrast of the pale ground color with the black markings. Expanse, 82 mm. 1 ♀. Wells, Elko Co., Nevada. From the late Mrs. Caroline Chase. Type, coll. James S. Bailey.

This I believe is a true *Cossus*, although the ♂ is not known to me. The shape of the wing is as in *centerensis*. The structure is that of *Cossus*, and not of *Prionoxystus*. The thorax is subquadrate, the vestiture short and thick. The interspacial black dashes along the primaries subterminally distinguish it specifically. The pre-apical transverse black streak or line resembles that of *C. centerensis*. The hind wings are faintly reticulated. The ground color is a yellowish white. The black blotches on fore wings of *robiniæ* are here wanting, while there is a diffuse discal shade blotch, another above and beyond it on costa, and the wing shows a wide, soft, blackish shading, obliquely edged inwardly and covering the outer portions of the wing. Except the antennæ my type is perfect. Beneath it is strongly marked, and reminds one of *C. robiniæ* Peck, but the shape of the wing is not like that species. The thorax is black above, not gray with black stripe on tegulæ, and the collar is discolorous, pale yellowish gray. This species ought to be recognizable. The shape of the thorax is like *Cossus*, as is the vestiture, so that I am not prepared to find that the male has the peculiarities of *C. robiniæ* and *querciperda* Fitch. I hope Western collectors will solve the question. But I cannot regard *angrezi* as having anything to do with the question of a Western representative of *robiniæ*. From Herrich-Schaefer's figure, and what has been published, I believe that *robiniæ* is found across the continent.

PRIONOXYSTUS ROBINIÆ Peck.

I have a female with extended ovipositor. We have probably only one species, reaching from California to the East, and this is phytophagic, feeding on the oak, willow, as well as the locust and other trees. No difference by which these forms can be separated is appreciable. The female is redescribed as *crepara* by Dr. Harris. The insect was common in 1882 in different localities in New York State.

STRUCTURE.—The female antennæ are pectinate. The terminal segment of the abdomen narrows and becomes elongated and cylindrical towards its extremity. The male secondaries are half the size of the female's and obliquely and sqarely cut off along external margin, being also discolorous and of a bright yellow. The thorax is long and narrowed, elevated in front of the fore wings. The head is longer and more projected compared with *Cossus*, the prothorax narrowing anteriorly, neck-like. The labial palpi are longer and more distinct. The fore wing is more produced apically, longer and narrower; the outer edge less full and more oblique. The vestiture is sparse, thin, flatly laid on in body and wings. The hard chitinous tegument is less hidden, and the whole insect has a certain coleopterous aspect, reminding us of the wood-boring *Cerambycidæ*, such as *Prionus*, quite strongly. The aspect is not moth-like, but hard and chitinous. Just as there is a certain resemblance between different species feeding on a particular plant, as the pine-feeders, so do all borers have some points in common. The generic characteristics all hold good with the second species of this genus.

PRIONÓXYSTUS QUERCIPERDA Fitch.

(Plate II, Fig. 4.)

This species is smaller than *robiniæ*, the ♀ expanding 46 or 47^{mm}, the ♂ about 10^{mm} less. The male hind wings seem translucent, but on holding them obliquely in certain lights the yellow tint may be seen plainly. This smaller and rarer species occurs also in Texas. It is freer from reticulations and more transparent than any other form.

We have representatives of four genera of *Cossidæ* in the United States, viz., *Hypopta*, *Cossus*, *Prionoxystus*, and *Cossula*. As to the species described under Cossus, several are incompletely described, and none are now so well known as *C. centerensis*, which has been studied by my son, Dr. Theodore P. Bailey, and myself.

COSSULA MAGNIFICA Bailey.

(Plate II, Figs. 1, 2, and 3.)

[This species was described by Dr. Bailey in Papilio for July, 1882 (Vol. II, No. 6, p. 94), with notes upon its habits. The larva bores into live-oak (*Quercus virens*) in Florida. No new matter was prepared on this species at the time of his death, and we do not consider it necessary to repeat the original description.—C. V. R.]

REPORT ON THE EXAMINATION OF RAW SILKS.

By

WILLIAM McMURTRIE, E. M., PH. D.

Professor of Chemistry in Illinois Industrial University.

CHAMPAIGN, ILL., *February* 8, 1883.

SIR: I have just completed the examination of the samples of silk you offered for measurements of fineness and tensile strength of the fibre, and I take pleasure in submitting herewith the results we have been able to obtain, together with a brief description of the methods employed in the examination, and some considerations of the relations exhibited in the results.

Very respectfully,

WM. McMURTRIE.

Prof. C. V. RILEY,
U. S. Entomologist.

REPORT.

Description of the material.—The material furnished for the examination about to be described consists of eight samples of cocoons of various races of silkworms, grown in this country in different localities, with different kinds of food. Each sample was inclosed in a box bearing an inscription by which the sample was distinguished, and the latter is to be found in Table I at the bottom of the column, giving the results of the measurements of the fineness of the respective samples. No measurements were made to determine the size of the cocoons or the weight of the silk they are capable of yielding, for the latter would involve the use of appliances not at our disposition. But it may be said that they were of good size, perfectly firm and uniform, clean and of good color; in fact, from all appearances, evidently of excellent quality. This constitutes all the information we have concerning the history of the cocoons.

Object of the examination.—The examination, as requested, was more to determine the quality of silk grown in the United States as compared with that obtained in European culture. For the purposes of the comparison we must refer to the published works giving the fineness and strength of the European raw silks, since we have had no material with which to determine the necessary data. From the appearance of the cocoons, however, there can be little doubt that the comparison will prove favorable to the American product.

Preparation of the material for examination.—As has already been intimated, we were provided with no special apparatus for reeling the silk from the cocoons, and specimens for the measurement of the fineness and one set for determination of the tensile strength were obtained by simply cutting open the cocoons, separating the layers by pulling them apart, and taking portions of fibre at random from each part. No attempt was made to determine in this examination differences in the quality of the fibre dependent upon the location of the part in the stratification of the cocoon, and hence the period of the spinning operation at which it was formed, both because the time at our disposal for making the examination had been limited and because this did not constitute a principal object in the examination desired. There is no doubt, however, that an investigation with this regard would furnish results of great interest and value.

The fibres separated in this way were designated as "dry;" that is, no moisture was employed in their separation. It is well known that the strength of the cocoon depends upon the glutinous character of the fibre on the instant of its issue from the spinnerets of the insect, and that the glutinous matter covering the fibre and forming a portion of its constituent structure readily softens in warm water. And it is further well known that this principle is applied practically in the industrial processes of silk reeling. To determine what influence this may have upon the fibre, we submitted a series of the cocoons to the action of warm water, and when they were sufficiently softened secured the end of the fibre and wound it upon slips of card-board, thus applying in a crude way the process of reeling. The fibre so obtained has therefore been designated as "wet." The influence of the treatment to which the fibre is subject in this process of separating it will be discussed later on, and is manifest in the results given in Table II.

Measurements of fineness.—If the fibre of raw silk be examined with a microscope of sufficiently high power, it appears to consist of a more or less flattened strip, somewhat depressed through the middle, so that its cross-section may be likened to the longitudinal section of a dumb-bell (∞), as shown in the figure. This is explained by the fact that the fibre in the glutinous condition is discharged by the worm in spinning, from the spinnerets located on the under side of the head, near the mandibles. As they pass out and are stretched by the worm in its to-and-fro motions in spinning, the two fibres are cemented together more or less firmly according to the rapidity of spinning.

Sometimes these primary fibres, as they may be termed, are separate and free from each other, and each is an almost perfect elongated cylinder. But in most cases they are firmly joined, and the two form a compact whole, constituting the raw fibre of the cocoon. It is plain, therefore, that this raw fibre is not cylindrical but ribbon-shaped, and that it has two lateral axes of different lengths, so that on some accounts a single measurement of a fibre does not represent its fineness, while at

the same time there is danger that in taking the measurements with the microscope the longer axis of the fibre may be taken in some cases, while in others the shorter axis may be inadvertently chosen. So also it may to some appear extremely desirable that in order to fairly determine the fineness of the fibre both axes should be measured, and there is much of reason in this opinion. On the other hand, if we bear in mind that the breadth of the ribbon will depend upon the diameter of the individual fibres constituting the raw fibre, it will be seen that the breadth of the fibre, or its longer lateral axis, may be accepted as a fair representation of the degree of fineness of this condition of the staple.

The method of taking the measurements of fineness is therefore as follows: The cocoon is cut open and separated into the different layers of which it is made up. A small tuft of fibres is then cut from each, taken at random. These are then cut to suitable length and mounted upon the glass object slide for microscope, immersed in Canada balsam, and covered with a thin glass circle. When the cover is in place the slide is gently warmed and laid aside for the balsam to dry and harden. When ready for the purpose each slide is placed upon the stage of the microscope, the fibres successively brought into focus, and the width of the image at its widest part measured by means of an eye-piece micrometer, which has been standardized by means of a stage micrometer graduated to centimillimeters. The relative measurement taken in this way is reduced to the absolute standard and the result entered in the record. The object of taking the width of the image at its widest part is to obviate the danger of measuring the image of the fibre turned more or less with its edge toward the eye, a difficulty that would materially vitiate the result.

In experiments made in this connection, as well as in the measurements of wools and cottons in a similar way, it has been found both advisable and necessary, in order to arrive at satisfactory conclusions concerning the property under consideration, to make measurements of at least thirty fibres in each sample. For purposes of comparison every measurement is entered upon the record, which is given in the following table:

TABLE I.—*Measurements of the fineness of raw silk.*

Catalogue number of samples.	I.	II.	III.
Actual measurements in centimillimeters.	3.00	2.625	3.25
	2.50	3.50	2.625
	3.50	4.625	2.75
	3.75	2.50	2.875
	2.875	2.625	2.75
	3.75	2.50	3.50
	3.75	2.875	2.75
	3.875	3.875	3.25
	3.50	3.25	2.75
	2.625	2.75	3.25
	2.875	2.75	2.50
	3.00	2.625	3.00
	3.50	3.00	3.00
	2.50	3.00	3.00
	3.50	3.25	3.00
	2.375	3.00	2.625
	3.75	2.25	2.50
	2.75	2.625	2.375
	3.00	2.875	2.625
	2.50	2.25	2.50
	3.125	2.75	2.50
	3.25	3.00	2.75
	2.50	2.75	2.75
	3.125	2.625	2.50
	2.625	2.875	3.00
	3.375	3.00	2.125
	2.875	2.50	2.375
	3.50	2.75	3.00
	2.375	2.50	2.75
	3.50	2.75	2.625
	2.75	2.50	2.875
	2.75	3.00	2.125
	3.25	2.875	3.00
	2.625	3.00	2.75
	3.00	2.875	2.50
	2.625	2.75	2.50
	3.125	2.625	2.50
	2.75	2.75	3.00
	2.875	2.375	2.25
	3.00	3.125	2.75
	2.00	3.25	3.25
	3.375	2.25	2.875
	3.25	3.375	3.25
	3.50	2.625	2.75
	2.50	3.25	3.00
	2.75	2.75	2.50
	3.00	2.75	3.00
	3.25	3.25	2.50
	3.00	3.25	2.50
	2.25	3.00	2.75
Average	3.015	2.878	2.748

	I. In centimillimeters.	I. In thousandths of an inch.	I. In fractions of an inch.	II. In centimillimeters.	II. In thousandths of an inch.	II. In fractions of an inch.	III. In centimillimeters.	III. In thousandths of an inch.	III. In fractions of an inch.
Recapitulation:									
Highest	3.875	1.5255	[illegible]	4.625	1.8208	[illegible]	3.50	1.3779	[illegible]
Lowest	2.00	0.7874	[illegible]	2.25	0.0858	[illegible]	2.125	0.8366	[illegible]
Average	3.015	1.1870	[illegible]	2.878	1.1330	[illegible]	2.748	1.0818	[illegible]

	I.	II.	III.
Number of measurements above average	21	19	30
Number of measurements below average	29	31	20
	Yellow Japanese; mulberry.	Yellow Japanese; Osage orange.	Riley's yellow Japanese; Osage orange; 11 years.

TABLE I.—*Measurements of the fineness of raw silk*—Continued.

Catalogue number of samples.	IV.	V. Yellow.	V. White.
Actual measurements in centimillimeters.	2.375	2.125	2.00
	2.50	2.50	2.50
	2.00	2.50	3.00
	2.75	2.50	2.75
	2.00	2.375	2.625
	2.50	2.25	2.25
	2.75	2.375	2.50
	2.50	2.50	2.25
	2.50	2.25	3.00
	2.25	2.50	2.50
	2.75	2.50	2.50
	2.875	2.25	3.00
	2.625	1.875	2.25
	2.125	2.125	2.875
	2.375	2.75	2.00
	2.75	2.50	2.50
	3.00	2.50	2.00
	2.375	2.00	2.50
	2.75	2.75	2.50
	2.25	2.25	2.25
	2.75	2.875	2.50
	2.75	2.50	2.125
	2.50	2.375	3.00
	2.75	2.50	3.25
	2.25	2.25	2.875
	2.125	2.50	2.75
	2.625	2.50	2.50
	2.75	2.375	3.00
	2.875	2.50	2.25
	2.625	2.75	2.50
	2.50	2.50	2.50
	2.75	3.25	2.125
	2.625	3.00	2.125
	2.75	1.875	1.875
	2.50	1.75	2.75
	2.375	2.75	2.25
	2.50	2.375	2.50
	2.50	2.75	2.75
	2.25	2.625	2.375
	3.25	2.375	2.25
	2.625	2.50	2.50
	2.00	2.75	3.25
	2.50	2.25	2.75
	2.125	3.00	3.125
	2.625	2.75	3.00
	2.50	2.625	2.25
	2.75	2.50	2.25
	2.375	2.00	2.75
	2.50	2.25	3.00
	2.375	2.875	2.50
Average	2.513	2.465	2.528

	IV. In centimillimeters.	IV. In thousandths of an inch.	IV. In fractions of an inch.	V. Yellow. In centimillimeters.	V. Yellow. In thousandths of an inch.	V. Yellow. In fractions of an inch.	V. White. In centimillimeters.	V. White. In thousandths of an inch.	V. White. In fractions of an inch.
Recapitulation:									
Highest	3.25	1.2735	$\frac{1}{781}$	3.25	1.2735	$\frac{1}{781}$	3.25	1.2735	$\frac{1}{781}$
Lowest	2.00	0.7874	$\frac{1}{1269}$	1.75	0.6889	$\frac{1}{1451}$	1.875	0.7380	$\frac{1}{1354}$
Average	2.513	0.9893	$\frac{1}{1010}$	2.465	0.9704	$\frac{1}{1030}$	2.528	0.9952	$\frac{1}{1004}$
Number of measurements above average	21			30			17		
Number of measurements below average	29			20			33		
	Riley's white Japanese; Osage orange; 11 years.			Fasnach's black Thibet.			Fasnach's black Thibet.		

TABLE I.—*Measurements of the fineness of raw silk*—Continued.

Catalogue number of samples.	VI.	VII.	VIII.
Actual measurements in centimillimeters.	2.50	3.50	2.75
	2.50	2.75	2.00
	3.125	3.00	2.00
	2.00	3.00	2.50
	3.125	3.25	2.50
	3.00	2.625	3.00
	3.00	2.50	2.50
	2.75	3.00	2.625
	2.125	3.00	2.875
	2.75	3.25	2.50
	2.125	3.50	2.375
	3.50	3.375	3.50
	2.75	2.50	2.00
	2.25	2.875	2.50
	2.875	2.75	2.50
	3.00	3.50	2.25
	2.25	3.00	2.625
	3.00	3.25	2.375
	2.75	2.50	2.75
	2.375	2.75	2.50
	2.50	3.50	2.00
	3.25	3.50	2.50
	3.375	3.00	2.50
	2.50	3.25	2.25
	3.00	2.875	2.25
	3.00	3.25	2.50
	2.625	3.00	2.50
	2.75	3.00	2.75
	3.50	2.875	2.375
	2.875	3.00	2.50
	3.25	2.75	2.50
	2.875	2.875	2.00
	2.50	2.75	3.00
	2.50	4.25	2.25
	2.875	3.25	2.00
	3.25	2.50	3.25
	2.75	3.125	2.25
	3.50	2.75	2.25
	2.875	2.25	2.75
	3.25	2.75	2.50
	3.50	3.50	2.25
	3.00	3.25	2.625
	3.50	3.00	2.75
	3.00	2.75	3.00
	3.00	3.00	2.25
	2.50	3.50	2.375
	3.00	2.75	3.00
	2.50	3.125	2.50
	2.50	3.25	2.25
	2.75	3.375	2.25
Average	2.86	3.038	2.485

	VI. In centimillimeters.	VI. In thousandths of an inch.	VI. In fractions of an inch.	VII. In centimillimeters.	VII. In thousandths of an inch.	VII. In fractions of an inch.	VIII. In centimillimeters.	VIII. In thousandths of an inch.	VIII. In fractions of an inch.
Recapitulation:									
Highest	3.50	1.3779	$\frac{1}{725}$	4.25	1.6732	$\frac{1}{597}$	3.50	1.3779	$\frac{1}{725}$
Lowest	2.00	0.7874	$\frac{1}{1270}$	2.25	0.8858	$\frac{1}{1129}$	2.00	0.7874	$\frac{1}{1270}$
Average	2.86	1.1259	$\frac{1}{888}$	3.038	1.1960	$\frac{1}{836}$	2.485	0.9783	$\frac{1}{1021}$
Number of measurements above average	27			20			29		
Number of measurements below average	23			30			21		
	Crozier's. French, from Cevennes.			Crozier's, French Black. Worms white.			Croziers, French Black. Worms dark.		

The table will for the most part explain itself. The records of actual measurements are stated in céntimillimeters, and at the foot of each column of these is given the average of the thirty measurements represented in each one respectively.

In the recapitulation we give reductions of these averages to thousandths of an inch, and to fractions of an inch expressed in the vulgar fraction, in order that the figures may be more easily comprehended by all to whom they may be presented. In the same section we have given, similarly reduced, the highest and lowest measurements taken on each sample, while in down lines will be found a series of figures showing the number of measurements found above and below the average respectively. These serve to show at a glance the range of the measurement, and therefore express the degree of evenness and regularity found throughout the length of the fibre of each sample. They will therefore serve, to some extent, as an indication of the comparative value of the several samples.

At the extreme bottom of each column is given a copy of the inscription found on the box inclosing the sample represented. For the better comparison of the several samples we may submit the following condensed table giving the averages of the measurements stated in centimillimetres and thousandths of an inch:

Number of samples.	Average measurements in centimillimeters.	Average measurements in thousandths of inch.
I	3.015	1.1870
II	2.878	1.1330
III	2.748	1.0818
IV	2.513	0.9893
V.—Yellow	2.465	0.9724
V.—White	2.528	0.9952
VI	2.86	1.1259
VII	3.038	1.1960
VIII	2.485	0.9783

The differences here shown appear to be sufficiently wide to illustrate any differences in the condition of feeding and management to which the worms may have been subject during their development, but the data we have will not warrant our entering into any discussion of these interesting relations. There can be no doubt, however, that the complete history of the worms will furnish material for exceedingly interesting and valuable comparisons in this particular.

Measurements of strength and stretch.—The determinations of the tensile strength of the fibres were effected by the aid of a dynamometer specially constructed for use in the examination of wools and cottons, and described in "A Preliminary Report on the Examination of Cotton" submitted to the Honorable Commissioner of Agriculture in 1882. This

instrument is so constructed that the strain to which the fibre is subjected to break it, and the stretch it sustains previous to rupture, are simultaneously taken and recorded, and we have, therefore, to present in this connection two sets of results.

In making these tests the following method was employed: In the first place the cocoons were cut open and their layers separated, or they were submitted to the action of hot water and the fibres wound off upon pieces of card-board, each process furnishing the "dry" and "wet" specimens respectively described in a preceding paragraph. From the loose fibre thus obtained sections of suitable length were taken at random for the individual tests, the "*wet*" specimens having been previously thoroughly dried. The two clamps holding the fibres in the instrument during the tests were carefully set at a distance of 20 millimeters apart, so that this distance represents the length of the fibre submitted to the strain. Experiments with woolen fibres showed this distance to give the most uniform and satisfactory results, and is, therefore, accepted as a standard for all our work. Although no special experiments were made with this regard on the silk examined, there is little doubt that it would be found equally satisfactory.

In this part of the examination as in the measurements of fineness, we have adopted 30 as the best number of fibres to be tested to secure a satisfactory average, and as before, each separate result obtained was entered upon the record to be employed in any comparisons that it may appear to be desirable to name. For their more ready comparison the results obtained with the "*dry*" and "*wet*" specimens, respectively, are placed side by side. The following table contains the results we have obtained:

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK.

Catalogue number of samples	I.—Dry.				I.—Wet.				II.—Dry.				II.—Wet.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	2.75	2.25	10.50	2.50	10.25	2.00	10.00	3.25	3.00	3.75	11.75	4.50	10.75	1.50	16.00	3.50
	8.75	3.00	10.25	3.00	10.50	3.00	14.00	1.75	8.75	2.75	12.50	5.25	12.50	1.50	14.25	2.00
	3.50	3.75	11.25	3.75	10.00	2.75	11.00	1.75	2.50	3.25	11.50	4.25	15.00	2.25	12.50	1.25
	2.75	2.00	11.75	4.75	11.25	2.25	11.00	3.00	4.25	4.00	11.25	4.25	13.50	3.25	14.00	2.50
	4.50	2.25	8.75	3.25	13.50	3.75	11.75	3.50	5.00	3.00	11.00	4.00	14.25	2.75	13.75	3.75
	9.00	2.00	9.50	3.75	13.00	4.00	11.75	3.50	5.25	4.00	11.00	5.00	12.50	2.50	12.25	2.75
	11.25	1.75	8.00	3.00	10.00	2.00	10.00	2.25	10.50	2.25	11.50	4.75	10.50	1.25	14.00	4.00
	10.50	4.25	8.25	2.50	12.75	3.50	10.50	3.25	11.00	3.00	11.25	4.25	15.50	4.50	10.75	3.00
	11.25	3.75	8.00	3.00	12.25	2.00	13.50	3.50	5.25	4.75	11.50	4.50	11.00	3.75	11.75	2.00
	8.75	2.50	8.25	3.25	12.25	1.25	11.00	3.25	8.00	3.25	10.75	5.00	10.00	2.25	10.75	1.75
	13.00	2.00	6.00	1.50	11.50	3.75	12.00	4.00	11.00	3.75	4.25	4.00	12.00	3.00	11.00	3.25
	9.25	3.00	8.00	2.50	11.75	4.75	12.50	4.75	11.00	3.75	4.25	5.00	11.50	3.00	11.25	3.25
	12.00	2.25	5.50	1.75	10.00	2.25	10.00	2.25	11.25	3.00	4.00	4.25	10.50	2.00	12.75	1.25
	10.00	3.00	6.25	2.25	11.00	3.25	12.50	3.25	11.00	3.75	3.50	2.50	10.50	1.25	12.00	1.75
	12.00	4.75	6.25	2.00	10.00	3.25	11.25	3.75	11.50	4.75	3.25	2.75	12.50	1.25	12.25	1.25
Totals	124.25	42.50	126.50	42.75	170.00	43.75	172.75	47.00	114.25	53.00	133.25	64.25	182.50	36.00	189.25	37.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	13.00	200.65	4.75	23.75	14.00	216.08	4.75	23.75	12.50	192.93	5.25	26.25	16.00	246.95	4.50	22.50
Lowest	2.75	42.44	1.50	7.50	10.00	154.35	1.25	6.25	2.50	38.59	2.25	11.25	10.00	154.35	1.25	6.25
Average	8.36	129.03	2.84	14.21	11.43	176.42	3.03	15.15	8.25	127.34	3.91	19.55	12.39	191.23	2.44	12.20

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	16	15	14	17	17	17	14	15
No. of tests below average	14	15	16	13	13	13	16	15

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples	III.—Dry.				III.—Wet.				IV.—Dry.				IV.—Wet.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams*	*mm.*
Actual measurements in grams and millimeters	2.50	4.00	4.00	2.75	9.25	2.25	10.50	2.25	2.50	1.00	8.50	3.25	10.25	3.50	12.25	2.75
	2.75	3.50	5.50	1.00	12.25	1.75	10.00	3.00	3.50	2.75	8.50	2.75	8.00	1.75	11.00	3.50
	2.00	3.75	6.25	2.25	8.00	1.75	9.75	1.25	3.75	3.75	9.75	3.50	8.50	3.00	9.25	2.25
	2.75	3.00	3.25	2.25	10.75	3.00	9.75	1.00	3.25	3.00	8.00	2.50	9.75	4.00	10.25	2.25
	2.50	3.25	6.25	1.50	10.00	3.25	5.00	1.75	4.00	4.00	8.00	2.75	9.00	2.25	9.25	4.25
	7.00	3.50	3.75	3.75	7.75	1.25	5.25	2.25	9.50	3.50	7.50	2.50	8.00	2.50	8.00	2.75
	9.25	5.00	4.00	3.25	11.50	1.75	11.50	1.75	11.00	5.00	6.00	2.00	9.25	2.25	8.25	1.50
	9.00	2.00	3.50	3.50	10.75	1.50	10.25	1.25	10.00	3.75	9.00	1.50	9.75	3.25	10.75	4.75
	9.75	2.50	4.50	1.75	5.50	1.25	11.75	1.75	9.00	3.00	8.00	2.25	9.00	3.00	9.00	3.75
	10.00	4.00	5.25	1.75	10.25	2.50	6.25	1.25	10.00	3.75	8.25	3.50	9.25	3.00	10.00	3.75
	10.00	2.75	3.25	3.25	8.75	1.75	10.25	2.75	11.75	1.75	6.00	2.75	9.50	1.25	10.00	3.25
	10.25	3.75	5.25	1.75	6.75	1.00	10.00	2.00	11.25	1.25	5.00	1.75	9.00	2.25	8.25	3.00
	10.50	2.00	5.00	1.75	8.00	1.50	10.00	1.75	9.75	2.25	6.00	2.50	8.50	2.75	8.75	4.00
	8.75	3.50	4.50	1.25	10.50	2.25	7.75	1.00	10.50	2.75	5.50	2.25	11.00	4.00	7.50	2.75
	9.00	3.00	3.25	1.00	12.50	2.50	10.25	2.00	10.25	3.00	6.50	3.75	10.50	3.00	8.00	2.75
Total	106.00	49.50	67.50	32.75	142.50	29.25	138.25	27.00	120.00	44.50	110.50	39.50	139.25	41.75	140.50	48.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	10.50	162.06	5.00	25.00	12.50	192.93	3.25	16.25	11.75	181.36	5.00	25.00	12.25	189.07	4.75	23.75
Lowest	2.00	30.87	1.00	5.00	5.00	77.17	1.00	5.00	2.50	38.59	1.00	5.00	7.50	115.76	1.25	6.25
Average	5.78	89.21	2.74	13.70	9.36	144.47	1.88	9.40	7.68	118.54	2.80	14.00	9.33	144.00	3.00	15.00

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	12	17	19	12	18	13	12	12
No. of tests below average	18	13	11	18	12	17	18	18

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples	V.—Dry yellow, split fibres.				V.—Dry white, split fibres.				V.—Dry yellow.				V.—Wet yellow.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	5.50	3.75	4.50	3.25	4.50	3.25	4.00	1.50	5.50	2.50	10.00	3.50	6.25	1.50	8.00	3.50
	5.00	3.25	4.00	3.75	4.25	2.75	3.25	1.75	6.75	4.75	9.50	3.00	6.75	2.00	7.00	3.25
	4.50	1.25	4.00	4.00	3.00	1.00	5.25	3.25	6.00	2.75	11.00	4.25	7.00	1.50	8.00	2.00
	5.50	2.75	4.50	2.75	3.00	1.00	3.50	1.25	5.75	4.25	9.00	2.75	7.75	1.75	6.50	2.00
	6.00	1.25	4.50	3.00	3.25	1.50	3.00	3.00	5.00	2.25	10.50	4.00	6.00	2.00	8.25	3.25
	4.00	3.75	4.25	5.00	4.50	4.75	6.50	2.00	8.75	3.25	9.50	5.00	12.25	1.75	7.00	2.25
	4.00	2.75	5.00	4.50	4.00	2.75	4.75	1.00	8.75	4.75	9.00	4.50	6.25	2.50	9.50	1.75
	5.00	5.25	4.00	4.50	3.25	1.50	5.50	2.00	9.50	4.00	9.25	4.50	8.75	3.25	10.50	3.75
	5.00	4.75	4.00	3.25	4.50	3.75	3.50	2.25	9.25	2.00	6.00	1.25	8.75	3.00	8.75	3.00
	4.50	5.25	4.00	3.25	3.50	2.25	5.00	1.50	8.00	2.25	5.25	3.25	6.50	1.75	7.00	3.00
	3.50	3.50	3.25	2.75	4.00	4.75	2.50	3.25	11.00	4.75	5.00	2.00	9.25	2.75	11.00	2.00
	3.50	2.75	3.75	3.25	3.25	3.00	5.25	2.50	9.25	4.25	5.25	2.25	6.75	1.25	6.00	1.75
	3.75	3.00	3.25	2.25	3.25	3.00	2.25	2.00	12.00	1.75	5.75	2.25	7.00	1.75	7.50	1.75
	5.00	5.50	2.75	3.25	4.75	3.50	2.25	2.25	10.00	3.25	9.00	4.00	8.25	1.25	7.75	2.25
	4.25	3.25	3.75	3.25	3.75	3.00	2.25	3.75	10.75	2.75	9.25	4.25	7.50	2.25	6.25	1.75
Total	69.00	52.00	59.50	52.00	56.75	41.75	58.75	33.25	126.25	49.50	123.25	50.75	115.00	30.25	119.00	37.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	6.00	92.61	5.50	27.50	6.50	100.32	4.75	23.75	12.00	185.22	5.00	25.00	12.25	189.07	3.75	18.75
Lowest	2.75	42.44	1.25	6.25	2.25	34.73	1.00	5.00	5.00	77.17	1.25	6.25	6.00	92.61	1.25	6.25
Average	4.28	66.06	3.47	17.35	3.85	59.42	2.50	12.50	8.32	128.42	3.34	16.70	7.80	120.39	2.25	11.25

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	14	12	14	14	19	14	12	13
No. of tests below average	16	18	16	15	11	16	18	17

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples	V.—Dry white.				V.—Wet white.				VI.—Dry.				VI.—Wet.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	4.00	2.25	9.75	3.00	11.00	2.75	6.75	2.75	10.50	4.00	15.50	5.00	12.00	2.00	13.00	2.00
	4.25	3.25	5.50	2.00	10.50	4.00	10.50	2.75	10.50	4.75	15.50	4.25	11.25	2.75	12.00	3.50
	4.00	1.75	5.75	2.25	11.75	2.00	9.00	2.00	8.00	2.50	15.00	4.25	12.25	3.00	13.25	1.25
	3.75	2.25	10.00	3.00	11.25	2.00	10.25	2.25	11.00	4.00	14.00	3.25	12.00	2.25	12.25	3.25
	3.75	2.25	6.50	1.75	11.25	3.00	9.50	1.75	8.00	1.25	15.00	4.25	11.75	3.00	12.50	4.25
	8.00	3.25	5.25	1.75	9.75	1.75	11.00	2.25	16.00	1.75	14.50	4.25	10.25	2.50	10.50	2.00
	7.75	3.00	6.00	1.25	11.25	2.75	8.00	1.75	17.25	3.25	13.00	3.75	12.00	1.25	13.00	2.00
	9.50	3.25	4.00	1.50	11.00	3.50	11.00	3.00	16.00	5.25	13.25	3.75	11.00	3.00	8.00	1.75
	9.00	3.25	4.25	1.25	11.25	2.75	9.25	1.75	15.50	4.00	12.50	2.25	10.25	2.00	10.50	2.75
	7.00	4.00	6.25	2.75	11.00	4.00	10.00	3.75	13.50	3.75	12.25	2.25	11.00	3.00	8.00	2.50
	8.50	3.50	4.00	1.50	6.75	1.75	8.00	1.73	11.00	1.75	5.50	1.25	9.00	2.25	12.00	3.25
	8.50	2.75	5.25	2.25	7.00	1.25	9.25	2.25	13.00	2.50	7.25	1.25	8.00	1.75	12.00	3.75
	8.00	2.50	4.50	1.25	8.00	1.75	10.25	1.75	11.75	2.75	5.25	1.00	8.25	2.75	11.25	3.25
	7.75	1.75	4.25	2.25	10.00	3.00	8.75	2.50	13.00	3.50	7.50	2.00	10.00	2.25	13.50	3.75
	8.50	3.50	5.25	2.25	11.00	3.00	10.00	2.75	14.00	3.00	6.25	1.50	11.50	3.00	13.00	3.50
Total	102.25	42.50	86.50	30.00	152.75	39.25	141.50	35.00	189.00	48.00	172.25	44.25	160.50	36.75	174.75	42.75

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	10.00	154.35	4.00	20.00	11.75	181.36	4.00	20.00	17.25	266.25	5.25	26.25	13.50	208.37	4.25	21.25
Lowest	3.75	57.88	1.25	6.25	6.75	104.18	1.25	6.25	5.25	81.03	1.00	5.00	8.00	123.48	1.25	6.25
Average	6.29	97.08	2.42	12.10	9.81	151.41	2.48	12.40	12.04	185.83	3.08	15.40	11.18	172.56	2.65	13.25

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	13	13	18	15	18	17	18	16
No. of tests below average	17	17	12	15	12	13	12	14

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples	VII.—Dry.				VII.—Wet.				VIII.—Dry.				VIII.—Wet.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	8.50	6.00	9.50	3.75	10.00	1.25	10.00	1.75	8.25	4.25	8.25	4.25	5.25	1.75	7.00	2.75
	8.00	4.00	9.00	3.00	11.00	2.75	10.00	2.50	7.75	3.25	7.75	2.75	6.25	1.75	7.50	2.25
	8.25	3.25	9.00	3.75	11.25	2.00	10.50	4.00	8.25	4.00	8.25	2.75	6.50	3.25	5.75	1.75
	9.25	2.75	10.00	3.00	10.25	4.00	10.50	2.50	7.75	3.50	8.25	3.25	7.50	3.50	7.25	4.00
	7.75	4.25	10.50	3.50	11.00	3.25	12.50	3.00	8.75	3.25	8.75	3.50	7.75	2.25	8.00	3.75
	13.00	4.00	6.00	3.25	12.00	2.75	12.00	2.75	9.75	2.75	9.25	2.25	6.75	3.00	6.75	2.25
	13.00	3.25	7.25	3.75	10.50	1.75	12.00	2.00	9.00	1.50	8.75	3.00	7.50	2.25	5.00	2.25
	12.25	2.75	5.50	2.25	10.75	1.50	12.25	2.25	8.50	1.25	9.25	1.50	7.00	1.25	8.50	3.50
	11.50	2.75	6.50	3.25	12.50	2.00	10.25	2.75	9.50	3.75	9.00	3.00	7.00	1.75	6.25	1.25
	12.25	3.00	7.25	4.00	11.25	2.00	10.50	1.75	9.25	3.50	10.25	2.25	8.00	3.00	7.50	1.75
	14.00	4.50	7.00	3.50	10.00	2.50	13.50	3.00	10.00	4.25	7.00	3.00	7.75	1.75	7.00	2.00
	12.25	3.50	7.75	3.50	9.00	2.00	12.25	3.25	12.00	4.25	5.25	2.00	6.75	3.00	7.00	2.00
	12.50	3.25	7.00	4.00	10.00	3.00	11.25	2.25	10.25	4.00	7.00	3.00	6.25	2.25	7.25	1.50
	15.00	5.00	6.00	3.25	10.75	2.75	9.25	2.00	10.50	4.00	5.00	2.00	7.25	1.75	7.50	4.00
	14.50	3.75	6.50	3.50	14.00	4.00	10.50	3.00	10.00	3.25	6.25	3.25	7.00	1.75	6.25	2.25
Total	172.00	56.00	114.75	51.25	164.25	37.50	167.25	38.75	139.50	50.75	118.25	41.75	104.50	35.25	104.50	37.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	15.00	231.52	6.00	30.00	14.00	216.08	4.00	20.00	10.50	162.06	4.25	21.25	8.50	131.19	4.00	20.00
Lowest	5.50	84.89	2.25	11.25	9.00	139.91	1.25	6.25	5.00	77.17	1.25	6.25	5.00	77.17	1.25	6.25
Average	9.56	147.55	3.58	17.90	11.05	170.55	2.54	12.70	8.59	132.58	3 08	15.40	6.97	107.58	2.42	12.10

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	12	12	12	14	16	16	19	10
No. of tests below average	18	18	18	16	14	14	11	20

Here, as before, we have given the actual measurements taken, the strains being stated in grams and the stretch in millimeters and per cents. In the recapitulation we have prepared a statement showing the averages of all the measurements taken with each sample respectively, as well as the highest and lowest results obtained in each, the strain in each case being reduced to grains and the stretch to per cents of the length. This will make the figures more intelligible to all who may be interested in them, and will render a comparison much more easy. In the lower lines we find a statement showing the number of measurements found above or below the average, as the case may be, for each sample.

In explaining the method of measuring the fineness reference has been made to the peculiar structure of the fibre, resulting from the mode of its production. This structure was decidedly marked in "dry" No. V. Here very many of the fibres were split either before the test or became split by the strain or at the instant of rupture. We find upon comparison of the results obtained in the tests of the split fibres in tests of whole fibres from the same cocoons that the latter are very considerably stronger than the former, though as regards the percentage of stretch there appears to be no very material difference between the two. And another peculiarity in the relations of the two is that the strength of the whole fibre appears from the averages to be about double that of the split fibres. Let us bring these averages together for more ready comparison. It will suffice to express the strain as grams:

	Split, grams.	Whole, grams.
V (dry yellow)	4.28	8.32
V (dry white)	3.85	6.29

On the other hand it may be mentioned that the uniformity in the strength of the fibres as regards the strain they are able to bear previous to rupture, as represented in the number of measurements found above and below the averages respectively, appears to be greater in the split fibres. The most important difference appears therefore to be in the strain representing the strength of the fibre, showing the importance of the more complete cementation of the fibres together as they issue from the spinnerets of the worms; and we may also learn from this something of the importance of maintaining the healthy and vigorous condition of the worms during their development, and more especially during the period when they are spinning their cocoons. The vigor and activity of the insects at the time may be very materially stimulated by careful regulation of the temperature, ventilation, and light, and not only the value of the fibre with this regard, but the condition and appearance of the cocoon, upon which its market value largely depends, may be modified by these relations. In this rather critical

period of the insect's existence, when from the circumstances the extreme care maintained throughout its development is likely to be relaxed, the silk-grower should be particularly watchful and observe the greatest care in keeping up the most favored conditions for the changes the young insect is about to undergo during the period here referred to.

These considerations will also serve to attract attention to the important influence of the methods employed industrially in reeling the silk from the cocoon upon the value of the staple. We have seen that when the separate fibres issuing from the spinnerets of the worm are fairly cemented together they are stronger than when they are not thus combined. And if we look over the Table II, given above, we shall find that when the cocoons have been wet, or have been soaked in hot water in order to separate the fibre, the latter as a general rule is stronger than when it has been separated dry. In the process of reeling the fibre becomes thoroughly soaked and saturated with water, so that the glutinous character becomes perfectly developed. As a result the primary fibres are more completely cemented together, while the ultimate fibres brought into contact passing to the reel are combined so perfectly that a maximum of strength must be secured. The influences of moisture upon the strength of the fibres will be noted upon comparison of the averages given in Table II. For convenience in making this comparison we have collected the necessary figures in the following table:

No. of samples.	Average strain required for rupture.	
	Dry reeling.	Wet reeling.
I	8.36	11.43
II	8.25	12.39
III	5.78	9.36
IV	7.68	9.33
V (yellow)	8.32	7.80
V (white)	6.29	9.81
VI	12.04	11.18
VII	9.56	11.05
VIII	8.59	6.97

We find here that, as a general rule, the higher results are in favor of the fibres that were reeled wet. The exceptions found are in samples V (yellow), VI, and VIII, and these may doubtless be explained by facts in the history of which we are not in possession.

In the table of results obtained with the dynamometer we have, as in the preceding relating to fineness, given in the recapitulation the highest and lowest as well as the average of the measurements taken. Below these may be found statements showing the number of measurements found above and below the average respectively. These figures serve to show the uniformity of the fibres with regard to the qualities represented. The extension of the fibre under the strain necesssary to

rupture is expressed in millimeters in a length of twenty millimeters of fibre, as well as in per cents. No special experiments were made to determine the limits of elasticity, and though the stretch will vary somewhat with the length of fibre held between the clamps of the instrument, limiting thus the character of the results, yet for the purpose of comparison the figures we have given will prove amply sufficient, and they will clearly show the differences in the quality and value of the samples submitted to examination.

Other qualities of the fibre and the cocoons have suggested themselves for investigation in the course of this work, but their examination has been precluded by the limited time at our disposal for the present study of this staple. We, therefore, submit these results in the hope that they may serve the ends desired.

EXPLANATION TO PLATES.

PLATE I.

Cossus centerensis.

1. Group of eggs as deposited, natural size.
2. Egg magnified 9 diameters.
3. Caterpillar from time of emerging to October 14—four months' growth
4. Caterpillar of one year and four months' growth.
5. Caterpillar of two years and four months' growth.
6. Mature caterpillar, three years old; ready to pupate.
7. Pupal cell.
8. Male pupa.
9. Female pupa.
10. Male Cossus, unspread.
11. Female Cossus.
12. Female Cossus, showing ovipositor.

PLATE II.

Cossula magnifica.

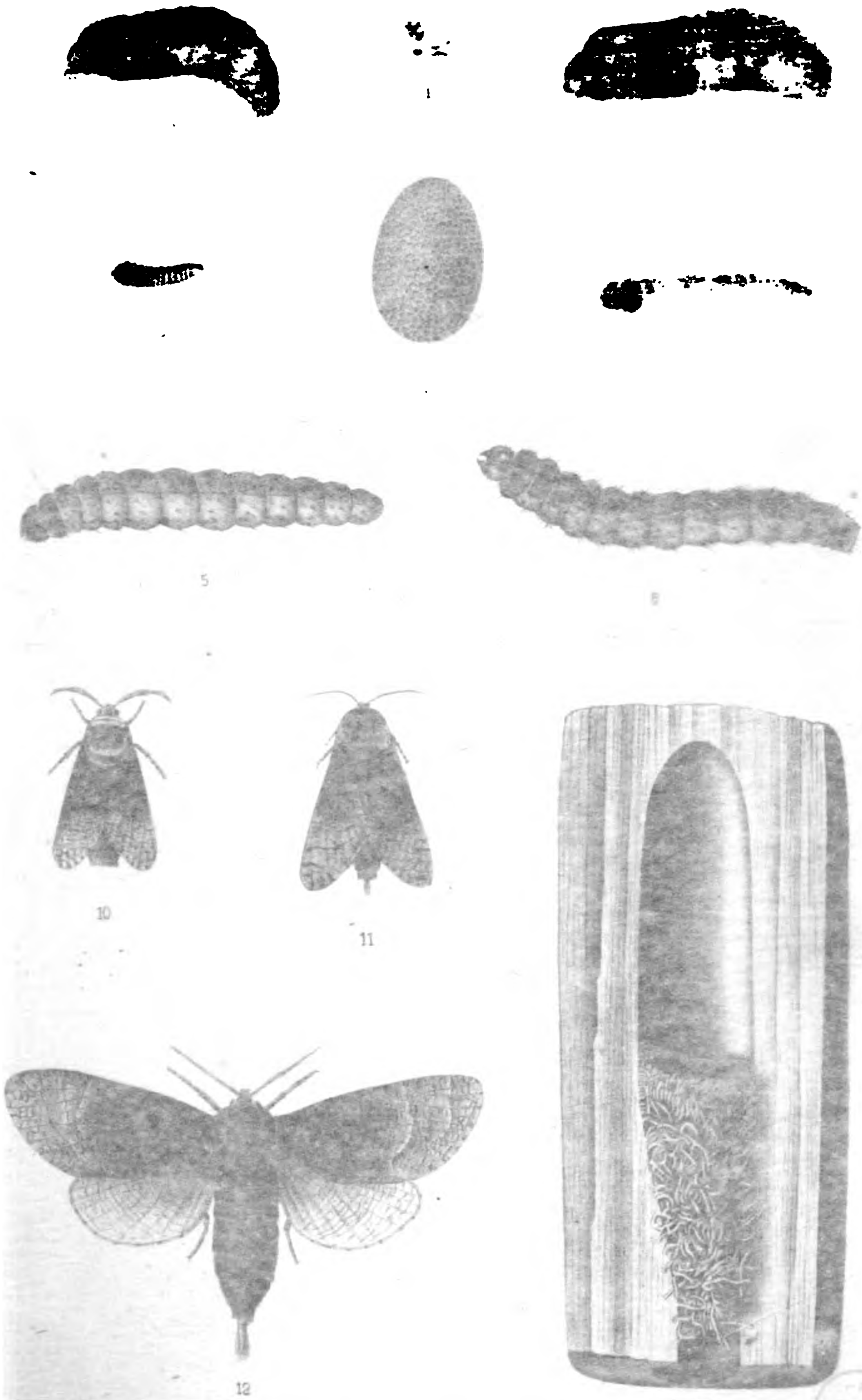
1. Pupa case of Cossula magnifica.
2. Cossula magnifica. Male.
3. Cossula magnifica. Female.
4. Cossus querciperda. Male.
5. Cossus querciperda. Female.
6. Cossus angrezi. Female.

PLATE III.

Silk fibres.

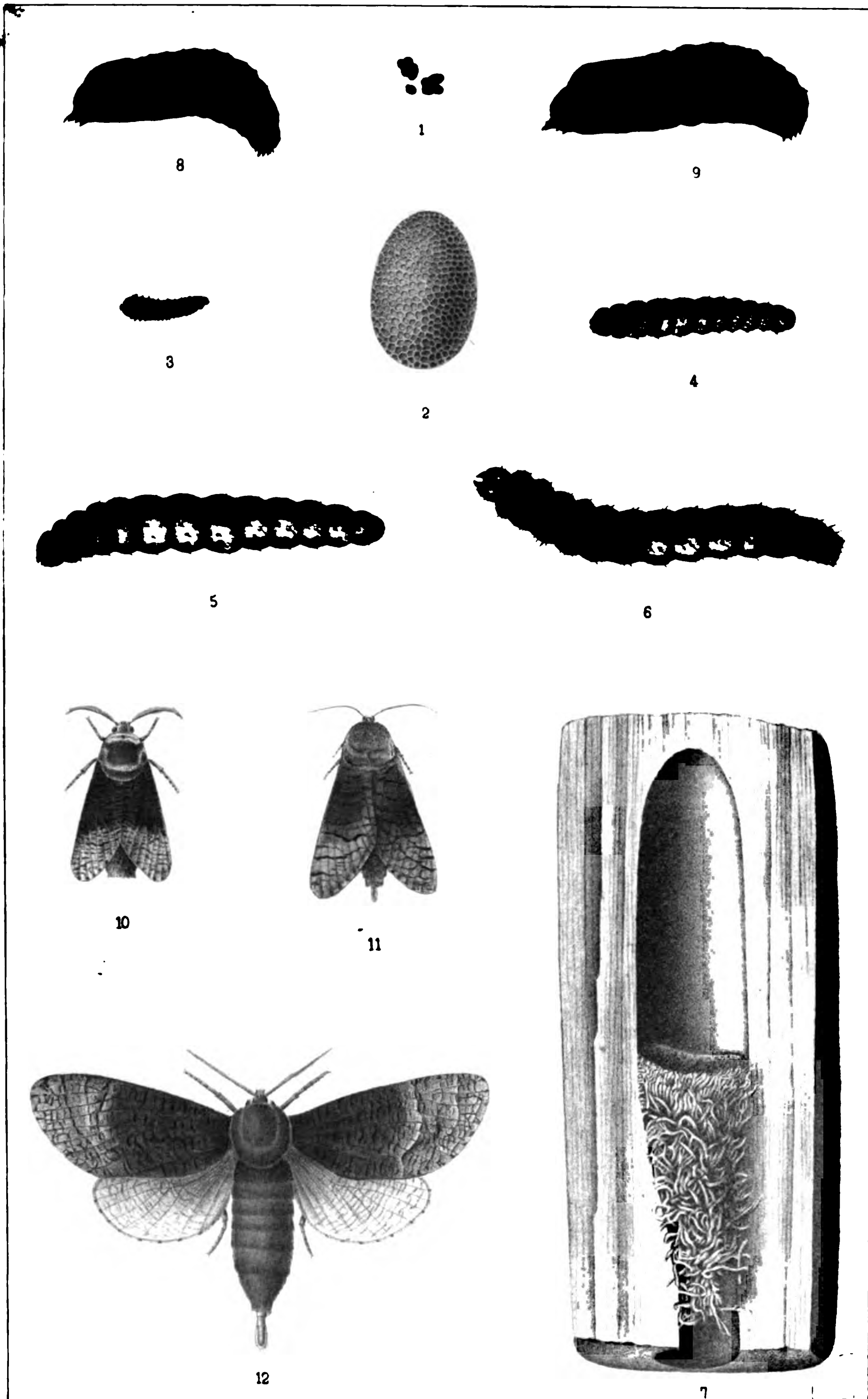
1. Fibre of white Cevennes race.
2. Fibre of Crozier's black race.

(Both figures magnified 240 diameters.)

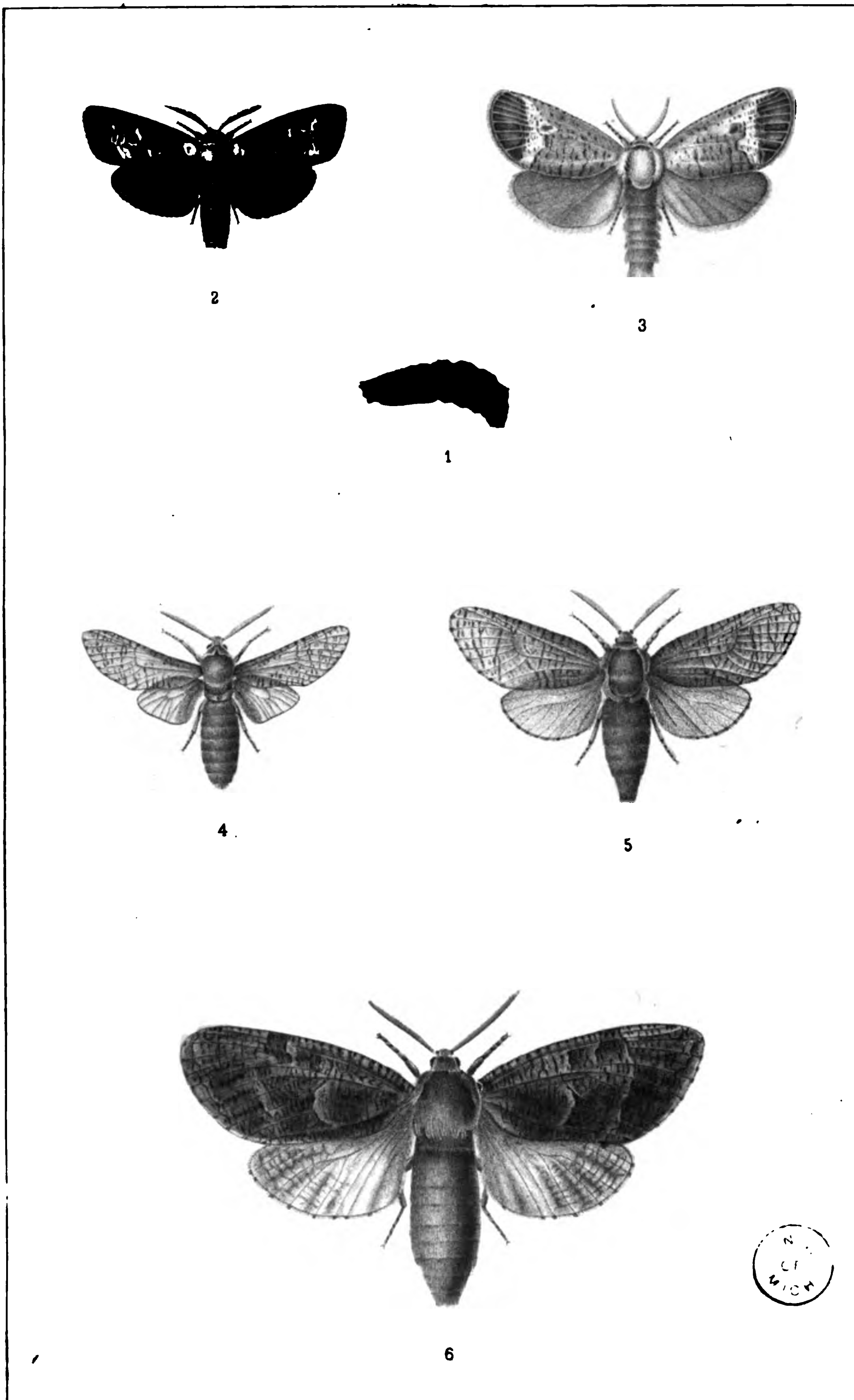


COSSUS CENTÉRENSIS.

ATE III.



COSSUS CENTERENSIS.



1, 2, 3. Cossula magnifica. 4, 5. Cossus querciperda. 6. Cossus angrezi.

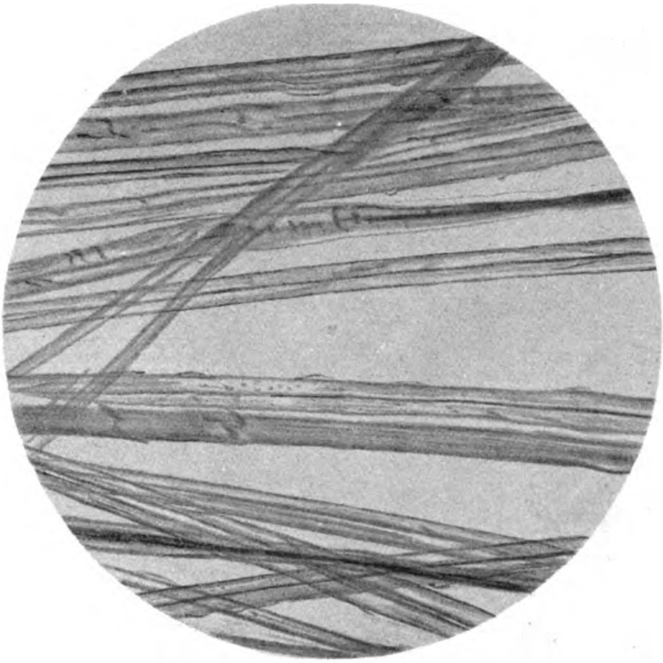


Fig. 1.

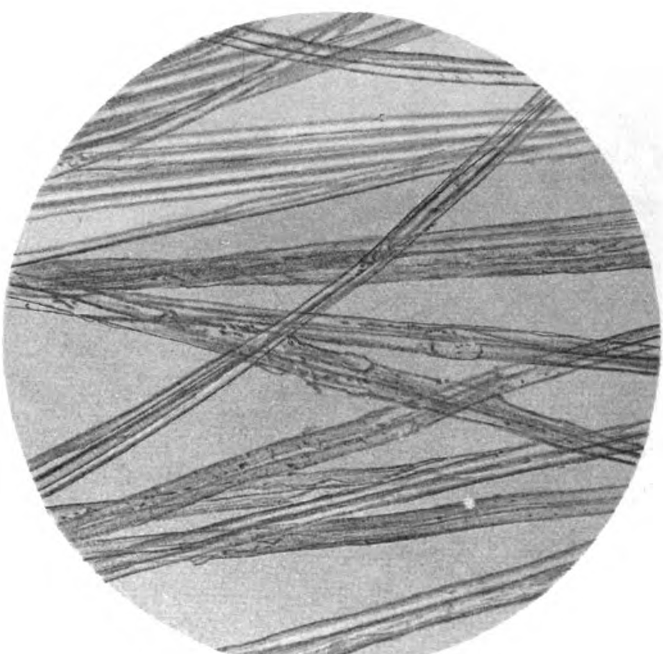


Fig. 2.

SILK FIBRE.

A. Hoen & Co. Lithocaustic, Baltimore.

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C.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 4.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST,

TOGETHER WITH

EXTRACTS FROM CORRESPONDENCE ON MISCELLANEOUS INSECTS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

8993—Bul. 4

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 8, 1884.

SIR: I have the honor to submit for publication Bulletin No. 4, from this Division, prepared under your instructions.

Respectfully,

C. V. RILEY,
Entomologist.

HON. GEO. B. LORING,
Commissioner of Agriculture.

TABLE OF CONTENTS.

INTRODUCTION.

This Bulletin contains a report by Mr. John B. Smith of his summer's observations upon insects injurious to the Cranberry in New Jersey and Massachusetts and to the Hop-vine in parts of New York; some notes by Mr. Lawrence Bruner of observations on the Rocky Mountain Locust and other insects in the Northwest in 1883; a preliminary report by Mr. John C. Branner on the results of his journey to Brazil as an agent of this Division, in connection with Mr. Albert Koebele, to study insects injurious to Cotton, to the Orange, and to Sugar-cane; and a report by Mr. Joseph Voyle on the effects of cold on Scale-insects. It concludes with extracts from the correspondence of the Division, including unpublished reports on experiments in the cultivation of Pyrethrum in different parts of the United States.

The damage to cranberry vines by insects, always severe, has been increasing of late years; yet our knowledge of the life-habits of the species concerned in the damage has been quite fragmentary. Beyond a few notes by Glover and Packard, and a short article by Dr. J. H. Brakeley, little has been published. I have long felt the need of more accurate knowledge of the insect drawbacks to cranberry culture and the best means of avoiding them, and Mr. John B. Smith, of Brooklyn, N. Y., was, therefore, specially charged with investigating them the past summer. His report will greatly help to a final and complete knowledge of the subject. Mr. Smith was also charged with the investigation of the insects injurious to the Hop-vine, and his report thereon is an important contribution to our knowledge of a subject that has so far received but little attention.

Mr. Bruner, with one assistant, explored, during the past summer, that section of the West between Central New Mexico and Idaho, following up the Rocky and the Big Horn ranges. On account of sickness he was unable to fully follow the latter part of the route mapped out for him, but succeeded in examining much territory that had previously not been examined. The chief object of the trip was to ascertain the status of the Rocky Mountain Locust, and, incidentally, to study the insects affecting the chief crops of the plains and mountain regions. As already indicated in my annual report, the results justify the conclusion that there will be comparative immunity from the ravages of the Rocky Mountain Locust in the trans-Mississippi country during the present year, 1884.

Mr. Branner's report is preliminary to a more extended one, but gives a definite idea of what work was accomplished during the Brazilian trip, and, with the statement of his instructions, will indicate the objects of the trip and the important bearing of the information on the work of the Division.

Mr. Voyle, in his report, gives the results of experiments by which he has determined the amount of cold which Scale-insects can bear, thus settling a point which has long been in dispute among orange-growers.

C. V. R.

REPORT UPON CRANBERRY AND HOP INSECTS.

BY JOHN B. SMITH.

SIR: Herewith I transmit my report on cranberry and hop insects, to the study or which, under your direction, I devoted the past summer. The notes with which you furnished me, and the aid and information given me during the summer in several difficult matters, materially lightened the work, and enabled me to report more fully than would have been otherwise possible. The damage done to both cranberries and hops this season was great—greater than it had been for years past—and fully justified your selection of these plants as requiring special investigation. For the determination of larvæ which I failed to raise to maturity, and for the notes on the insects raised from larvæ sent you, I desire also to express my thanks.

Respectfully submitted,

JOHN B. SMITH.

Prof. C. V. RILEY,
United States Entomologist.

CRANBERRY INSECTS.

To ascertain the history of these insects, I visited some of the cranberry bogs of New Jersey, and some of the Cape Cod bogs. At Cape Cod, Hyannis was the center of my investigations, and thence I visited the bogs at Harwich and vicinity, and Cotuit and vicinity. To Mr. George J. Miller, at Hyannis, I am indebted for information as to the location of the larger bogs, and as to the persons best able to aid me; to Captain Ames, at Cotuit, and Captain Cahoon, at Harwich, I am indebted for much information; while to all others, growers and those interested in the cranberry culture, I owe thanks for uniform courtesy and ready assistance. My researches in the New Jersey district were principally carried on in the vicinity of Hornerstown and Prospertown, and most largely on the Lahaway plantations, where Dr. J. H. Brakeley, himself no mean entomologist, and a very careful observer, gave me all assistance in his power, aided me in my experiments, and placed at my disposal his house and all his bogs. To him and to Mr. J. T. Brakeley I would express my sincere thanks for their courtesy. A diary kept by Dr. Brakeley, recording the first appearance of the insects in the various stages, the times of greatest plenty and the number of broods, together with the experiments looking toward their destruction and their success or non-success, proved of great service to me, as I knew thus, at least approximately, what I had to expect. The insect enemies of the cranberry are not alike in New Jersey and Cape Cod in all respects. The

"Fire Worm" (*Anchylopera vacciniana* Pack.) and the "Berry Worm" they have in common, and these are the most generally destructive insects. The most important of these is—

THE VINE WORM OR FIRE WORM.

(*Anchylopera vacciniana* Pack.)

This insect, the "Vine Worm," of Massachusetts, and "Fire Worm" of New Jersey, is in its perfect state a moth or miller, expanding less than half an inch, of a dark ash color, the fore wings being paler, dusted with brown and reddish scales, with white, narrow bands on the costa, alternating with broader, yellowish-brown bands, five of which are distinctly larger than the others; from four of them irregular, indistinct lines or bands cross the wing; the first is situated just beyond the inner third of the wing and is sometimes entirely and often partially obsolete, the portion nearest to the inner margin being usually distinct, while toward the costa it becomes obsolete. The second line is the largest and is distinctly bent once near the middle of the wing; the angle is rather darker than the rest of the band. The third line is oblique and becomes faint and sometimes obsolete before reaching the inner angle, and is forked on the costa. The fourth line is short, apical and diffuse. The apex of the wing is dark-brown and is acute and somewhat produced, while the margin below is somewhat excised. The secondaries are uniformly dark or smoky brown.

There are two broods of this insect; the first appears early in June and continues throughout the month, and the second appears the middle of July and continues to the middle of August. Stragglers are found from the end of May to the end of August, or even later.

The larva, when full grown, is slightly less than half an inch in length, of a rather dark-green color with a black, corneous head and collar; it is rather slender, very sparsely hairy, the hair being placed on small tubercles, and the head is not narrower than the middle of the body. The chrysalis is slender, the body being contracted at the base of the abdomen, on the rings of which are dorsal rows of spines.

On May 22, I visited Dr. Brakeley's bog, and obtained some larvæ about half grown from a small space which had not been flowed during the winter; May 23 one of the larvæ began to spin a slight cocoon, closed at both ends; May 25 it changed to a chrysalis, three-eighths of an inch in length and of a reddish-yellow color. June 2 the imago appeared.

At the time of my first visit to Dr. Brakeley's bog the water had not yet been entirely withdrawn, though the higher portions had been dry for nearly ten days. In those places where the water had just receded I found a large number of eggs of this insect. The egg is about 0.25^{mm} in diameter, of a waxy-yellow color, very flat or lentil-shaped, and closely attached to the leaf; in fact, it most nearly resembled a fly-speck. Further up, where the water had been off some time, I found young

larvæ, and even where the water had scarcely receded, larvæ evidently two or three days old were found. Close search revealed the fact that many of the larvæ had hatched beneath the surface of the water, and had perished from want of air. A majority of the eggs found contained fully developed but dead larvæ, while in many cases the larva had hatched and had lived for a day or two between the upper and lower surfaces of the leaf, before dying of lack of air. This first brood, as a rule, feeds for a day or two, or even longer, between the surfaces of the leaf, then climbs to the tip and spins up the terminal leaves, but does not usually eat off the tip so as to prevent further growth of the plant. As the plant develops, the more tender leaves only are attacked, and either the upper or under surface of the leaf is eaten. The larva never eats entirely through the leaf, but to the center only, and often only a few bites from different parts of the leaf. This first brood, as a rule, does no great damage, even though very numerous, because the larvæ feed very largely on the old leaves, and become full-grown just about the time that the vines begin to grow vigorously. About the 10th of June, or before, the moths of this brood appear in force. While I had seen that the larvæ were very numerous, I was yet perfectly astonished at the vast number of imagines I found flying in the dusk, for an hour and a half before darkness set in. At other hours of the day they can scarcely be induced to rise, but at this time they rise in swarms and fly and hover very much after the fashion of the mosquito.

The duration of the life of the moth appears to be about five or six days, and their eggs may be found everywhere; scarcely a spray escapes, and I have found as many as fourteen on a single spray and four on a single leaf. By the 15th of June the moths were most plentiful, but they continued more or less abundantly throughout the season. About the beginning of July the second brood of larvæ appears, vastly more numerous than the first; its power to do damage is very greatly enhanced, and a difference in habit and more opportunity for destruction render it still more dangerous. The cranberries blossom just about the time when the second lot of larvæ begin to hatch, and the young larvæ immediately attack the blossom or young berry, eating just enough to destroy vitality, and then attacking another blossom. When the berries and blossoms are either all destroyed, or the berries have fairly set, the larvæ no longer trouble them, but attack the leaves; and now they are not content to spin up only the tips and touch only what they eat, but, instead, they web up all the leaves of a spray and take a bite here, another there, and a third elsewhere, until they have destroyed every leaf on the spray. Where the vines are thick, two or even three sprays are spun together by a single larva which, by nipping from all the leaves, will destroy every one; the leaves lose vitality and turn brown rapidly, and the bog looks brown and dry "as though a fire had swept over it." Not leaves only, but berries also, are thus spun up and killed in like manner. Nor does it take the larvæ long to do their work. Dr.

Brakeley, well as he knew the enemy, was caught napping; on one bog he noticed the larvæ, but apparently not in force or doing any damage; busy with other bogs, he saw this, three days after, almost entirely eaten up. Senator Emsen, on a Saturday, noticed the larvæ on a 40-acre bog; he decided to attend to them in a few days, but three or four days thereafter the larvæ had destroyed the entire bog and were beyond being attended to.

The larvæ, when full grown, do not pupate in their habitations, but drop to the ground and spin up in any rubbish at hand. The end of July and the beginning of August bring the second brood of moths, and until the middle of September they can be found on the bogs. By that time the eggs are all laid, the last straggler disappears, and the vines begin to recover; and by the end of September, except for the absence of berries, there is little to show the amount of damage suffered by the bog. But the new crop is provided for; everywhere upon the leaves are the small yellow eggs, innocent enough in appearance, but these quietly maintain their vitality throughout the winter, under water, ready to awaken to life and mischief in the early spring. During the past season this insect has been unusually plentiful; everywhere on all the bogs visited by me they had done damage, some places more, some places less. They usually appear in one spot in a bog in small numbers—a stray moth or two having found their way to it—attract no particular attention until suddenly their progeny will devour the entire bog year after year. Occasionally they disappear as suddenly as they appear. One bog not far from Cotuit had never yielded a crop; year after year this insect had destroyed it, until the owner had almost despaired. This season he had made the most extensive arrangements to fight it—was prepared at all points to do battle, and calmly awaited its coming—but in vain; scarcely a larva was to be found on the entire bog, and on August 9, when I saw it, the vines were full of berries and everything pointed to a large crop.

REMEDIES.

An insect so destructive as this has, of course, been the subject of many experiments looking to its destruction, but they have been usually unsuccessful in the main end in view, viz., saving the crop, and this not because of any fault of the remedy, but simply because it was not applied at the right time. I made experiments with several insecticides, and ascertained what had been used by others, and was in most cases able to discover the cause of failure. The remedy recommended by Packard, and after him by Mrs. Treat and Mr. Saunders, is flowing the bog and letting it remain under water for two or three days. Unfortunately the vast majority of bogs require a week or more to flow them and half that time to run dry again, while many bogs could not be flowed at all in the summer. Nor could a bog be safely flowed at any time after the buds had formed and the blossoms had appeared; the result would be a de-

struction not only of the insects but of all hope of a crop as well. After the berries have fully formed, the bog cannot safely be submerged, for the hot sun would cause them to "scald." In one case in Cape Cod during a heavy rain-storm a bog was partially flowed; the sun came out strong before the water could be all drawn off; nearly half the berries were scalded. Yet the water can be advantageously used in two ways. Where there is an abundant supply it should be drawn off very early, say the middle of April or even earlier if the season is advanced. In parts of a bog not submerged, larvæ were found in considerable numbers on the 16th of April, and of these the imagines emerged June 2, or thereabouts.

Careful watch should be kept for the appearance of the larvæ, and when they are abundant and presumably all hatched, the water should be put on for twenty-four hours or longer. No harm will be done by allowing the larvæ to feed a few days before putting on the water, as they have only the old leaves, and do not eat off the terminal bud. Flowing a second time at this season will do no harm, as the sun is not hot enough to hurt the vines or the new shoots if they have appeared. The period of time required for the larvæ to hatch, varies with the temperature of the air, and with the temperature of the water with which they had been covered. This course has been tried by several growers with complete success. The larvæ are of course not all destroyed, but so few survive that no great damage is done, and they can be treated as hereafter described. Mr. Hopkins, of Hornerstown, reflowed his bog late in June or early in July for the second brood. I am informed that scarcely had the water covered the vines than the larvæ began appearing at the surface; it is their habit whenever their habitation is disturbed to slip out of the same and drop to the ground; the water was a disturbing element, and following their usual practice they found themselves afloat. Only a part of the bog could be flowed, and when the water was drawn off, a line of dead larvæ was heaped on the side toward which the wind had carried them. The weather was favorable, and there was no scald, but still a large portion of the berries were destroyed. On July 10, I examined the bog and could easily trace the line to which the water had reached. Scarcely a larva was found in the flowed portion, while the high parts to which the water had not reached were rapidly being eaten up. Last season, as I am informed, the insects being plentiful, the bog was entirely flowed; the insects were destroyed, but so was the crop. With a level bog and a large supply of water, a bog could be safely flowed for forty-eight hours at any time except when flowering, if a cool spell be selected for that purpose.

Where water is scarce and the bog cannot be readily flowed, another course must be pursued. Instead of drawing the water early, it should be kept on as late as possible, and should be drawn off very gradually *from below*. The reason for that is that the water becoming warm will cause the development of the larva in the egg, and will then suffocate

the larva as soon as it breaks the shell, or, indeed, in the egg. As the surface water is always warmest, it should be retained as long as possible and the cooler water drawn off from beneath. This can be easily done by building a second gate, not reaching to the bottom, outside the main gate, at a distance of about one foot from it. The water will rush in from below, rise to the level of the inside gate, and overflow without materially disturbing the surface water. This plan has been pursued by Dr. Brakeley, and on his bogs I had a chance to test it. May 22, the water had been about half drawn off, it having reached a temperature of 80° two inches from the surface. On that day I examined for eggs and larvæ in various portions of the bog. Where the water had not touched, the larvæ were abundant and half grown; where the water had covered, but had been off a week, no larvæ were found, and but few perfect eggs; while, on the contrary, many eggs in which were fully developed and defunct larvæ were found. Still there were eggs enough left to furnish a very respectable lot of larvæ, as will hereafter appear. Going down close to the water line many eggs were found largely containing fully developed but dead larvæ, but some also living; a few instances were seen where the larva had hatched beneath the water, had lived and eaten between the surfaces of the leaf for a day or two, and had then succumbed. One instance was noted where the larva was yet alive, and in the cavity in the leaf. This use of the water is not of course as successful as the first plan suggested, for while it destroys a large number of insects in embryo, a large number escape, owing to the difficulty of raising the water on an unequal bog to a sufficiently high temperature. Many bogs have 10 to 12 feet of water at the gates, and the vines at the edges scarcely covered; of course the deeper parts of the bog will not be warmed for a long enough time to force the development of the larvæ beneath the water far enough to destroy them, and many will thus escape. On a level bog, where the water covers the vines but a few inches, there is much greater hope of complete success.

On June 6, I again visited the bogs, and for several days experimented with insecticides. I found on those portions of the bog which had not been flowed full-grown larvæ, some pupæ, and a few imagos; on the portions which had been flowed, larvæ in all stages of growth; and on the portion first laid dry, some pupæ. The dates here given refer to the appearance and development of the insect on one particular bog only; the dates vary according to circumstances on other bogs.

White hellebore had been used by Dr. Brakeley in previous seasons with good success, and as soon as the larvæ became dangerous he turned his attention to them. On the part not flowed larvæ were abundant in May, and they were given a dose of hellebore; to ascertain what effect it had I covered a space of about three square feet, and this was thereafter not dosed.

The hellebore was applied in the form of powder, with a bellows con-

taining a receiver attachment, as explained in the annexed figure, *a* being the receiver in which the hellebore is placed from above, *b* the tin nozzle into which it drops through the narrow aperture at the bottom, and *c* the mouth of bellows. When examined in June the protected space was completely stripped of leaves, while the portion treated to hellebore, though badly damaged, showed the benefit of the treatment. To ascertain the effect of hellebore on the larvæ I placed several in a box of which the bottom had been dusted with hellebore. At first they paid no more attention to it than to so much dust; in ten minutes, after a continuous travel through the stuff, they began picking up particles with their mandibles; in twenty minutes they were very uneasy, and gradually became paralyzed, but were alive for more than an hour afterward. Ultimately the larvæ all died. The experiment was carried on in the open air. As to its effect when applied on the bog: It was applied twice on a portion of the bog where the larvæ were unusually abundant, and each time it seemed to reduce the number of larvæ, and undoubtedly did prevent their eating as much as they otherwise would have done, yet in the very spots where it had been thus freely used the moths appeared a few days later (June 11) by thousands. This was the result wherever it was used; it undoubtedly did much good, but I believe less by killing the larvæ than by forcing them to leave their poisoned quarters to seek food on the lower parts of the vine where they could do less harm. A drawback in applying this and other insecticides is that it is necessary to force it into the habitations of the insect, which is a difficult matter; moreover it is much more difficult to reach the second brood than the first, because the first spins up at the start only a leaf or two at the extreme tip, and must soon come out for food; the second brood, on the contrary, when it does begin to spin gathers up two or three sprays—enough for three insects—and so need not at any time come within reach of the poison, no matter how liberally applied outside its habitation. I am satisfied that not only contact with but the actual eating of white hellebore is requisite to destroy the insect. I consider hellebore valuable, but not the most valuable insecticide.

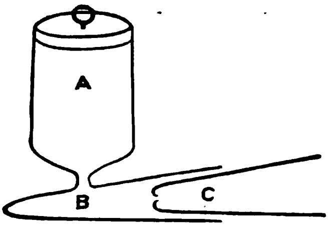

Fig. 1.—Powder bellows.

Bisulphide of Carbon.—Mr. Havens, of Prospertown, used a preparation said to be of this poison and handed me some to experiment with, but without giving me any further information as to the nature of the preparation, which was in the form of a brownish powder; it was tried on several larvæ, as in the case of the hellebore, and proved rather more active, but having the same general effect. I believe it to be open to the same objection there is to hellebore.*

* This could not have been the bisulphide of carbon.—C. V. R.

Copperas.—This poison is recommended as a certain cure by Senator Emsen, and he shows his faith in it by using it himself and recommending it to all others; but all experiments so far tried have failed to demonstrate its value as an insecticide—this insect of course in view. Dr. Brakeley has given it a thorough trial, and deems it valueless, and others give similar testimony. Decisive of the matter is the testimony of Mr. Emsen's secretary and manager. This gentleman informed me that he had transplanted some vines in a large jar, had placed therein a number of larvæ and so thoroughly soaked the whole with a solution of copperas that the leaves turned black; in a few days the larvæ had devoured everything, and were still perfectly healthy and ravenous.

Tobacco.—This is the favorite Cape Cod remedy, and the testimony gathered there is all in its favor. The tobacco is steeped in boiling water in the proportion of 1½ pounds to a gallon, and sprinkled on the vines, a gallon to a rod. The testimony of all who have so used it is to the effect that it kills the larvæ *wherever it reaches them*, but they find it somewhat difficult to reach them. There is a gentleman in Dennis, on the Cape, who makes somewhat of a business of preparing the decoction, and he claims that it is infallible. I was unfortunate in reaching Dennis at camp-meeting time, and did not succeed in finding this gentleman. Refuse tobacco of all sorts is used.

Paris green.—This poison has been used in a few instances that I know of, and probably in a quiet way to a considerable extent on the Cape. In New Jersey its use has been confined to a few, but wherever it has been used it has been a decided success. I have seen bogs on which it was used, parts only having been treated with it, and the difference in the appearance of the vines was striking: where it had been used the vines were green and flourishing, while elsewhere they were dry, unsightly, spun up and defoliated. It has been used stirred in water, a large tablespoonful to a pail of water, sprinkled on with a broom, and mixed with plaster, or rye flour. The latter is the preferable way. On Cape Cod the solution is preferred, in New Jersey the dry mixture is more favored. One grower mixed 3 pounds Paris green with 200 pounds cheap rye flour and scattered it broadcast while the dew was on the vines; it formed a slight paste and adhered everywhere; soon after not a larva was found on the part so treated. The advantage of this poison over all others is that it does not lose by exposure to the air as do all those previously mentioned: its disadvantage is that, applied when the berries have become fully formed, it sticks to them so closely that the gentleman referred to found the berries picked off the poisoned sections all more or less coated with the poisoned paste, which had dried on so closely that a heavy rain had not washed it off. Yet this poison may be safely applied early in the season to combat the first brood, before the berries have formed.

Pyrethrum, or Persian Insect Powder.—With this I have made a number of experiments: first as to its killing power. A few grains were

dusted on the bottom of box and several larvæ were introduced. In seeking to escape, all came in contact with a few particles: the effect was seen in half a minute; the larva began to squirm and to eject a greenish fluid from its mouth; in three minutes it was paralyzed; in fifteen minutes quite dead. Tried in a solution, one-quarter pound to 2 gallons of water, a single small drop produced a like effect, and this apparently irrespective of the spot where it touched the larva. Applied on the bog its effect was less satisfactory; the difficulty of reaching the larva in its hiding place was great and the powder lost power very rapidly: still a great decrease in the number of larvæ was noted. I tried it both in solution and putting on the powder pure. Later, Dr. Brakeley continued the experiments during my absence; the powder was thoroughly mixed with two and one-half times its bulk of cheap rye flour and applied with the bellows on a few rods of bog; at first no effect was perceptible, but two weeks thereafter the limits of the patch to which pyrethrum had been applied were distinctly traceable; where it had been used the vines were bright and fresh and were sending up vigorous shoots, while the surrounding space was all eaten up. The same mixture was tried on two larvæ which were placed in a vessel dusted with it. In a short time they became nervous, began a vigorous battle, and in a few minutes succumbed, though they did not die for some time thereafter.

Carbolic acid.—With this I made a few experiments which proved eminently unsatisfactory, killing the plants when strong enough to hurt the insects, and becoming harmless to insects and plants at about the same point. Squibb's solution, containing 1 per cent. of the crude phenols in water, was used as a base.

Kerosene.—With this the most extensive experiments were made, as it seemed to me best calculated to reach the insects; the vines are not easily affected by it, and it is penetrating enough to soak through a leaf or two and reach the insect in its hiding place. A number of experiments were tried to test its killing power. An imperfect emulsion of 2 parts kerosene to 1 part of milk was first used and diluted with 20 parts of water; a small drop was applied to a number of larvae; the effect was instantaneous; the larvæ seemed paralyzed at once, though they did not die for some time. A number of sprays of which the leaves at the tip were turned and spun up by larvæ were gathered, and a drop of the mixture was applied at the tip; the oil penetrated at once through every part of the leaves touched, and came into contact with the larva immediately, paralyzing it at once so that it could not leave the head, or, in some cases, it attempted to escape and was disabled before getting out. An emulsion of 2 parts kerosene to 1 part milk was made, mixed with 16 parts of water to one of the emulsion, and applied to the vines with a Lewis syringe. In the evening they were examined and a number of dead larvæ were found; traces of the oil could be everywhere seen, and where a drop had fairly struck a tip the larva was dead; for three

days dead larvæ were found (June 7 to 11), but thereafter no further effects were observed. Afterward the mixture was applied on a larger scale by Dr. Brakeley to the second brood, but with less success, because the amount of kerosene reaching the vines was insufficient to penetrate through the numerous shields of leaves protecting the larva, and so a large proportion escaped; another attempt, using but 10 parts of water to one of the emulsion, succeeded better and did not injure the vines. Mr. Bullock, of Prospertown, tried the mixture, 1 part emulsion to 10 of water, and says that it destroyed the larvæ; but while it did no injury to the vines it seemed to check the growth of the berries; I am informed that they eventually ripened but were undersized. No such effects followed the use of a 1 to 15 mixture used under my direction, but it was not so effective on the larvæ. Afterward a small space was treated with a 1 to 10 mixture where the larvæ of the second brood were nearly full grown, and the result was all that could be expected; most of the larvæ were destroyed and the vines were not hurt; berries unfortunately had been previously destroyed by the insects. The effect of kerosene on the eggs was then tried; pure kerosene was first directly applied to a few, and the effect was to destroy the vitality of the egg at once, it becoming loosened at the edges and flattening toward the center. The emulsion, diluted with 16 parts of water, was then applied to about two rods where eggs were numerous; for a few days thereafter eggs decreased in number, and no imagines were found on the spot; at the end of four days, however, the spot was as much frequented as ever by the moths, and eggs became more numerous; I then waited until the moths had nearly disappeared (August 20–23) and again applied kerosene to another spot of 4 or 5 rods, applying slightly more than a gallon to a rod and making the mixture 1 to 10. As the moths had not all disappeared and I was desirous of making my results exact, I marked a number of sprays and counted the eggs, marking only sprays containing a number (4–14), and setting close to them a stick marked with the number of eggs on the spray. The marked plants were treated precisely as was the balance of the patch, and the next day I examined the result; in a few instances the total number of eggs on the spray had increased, but fully 30 per cent. of the number marked on each spray had lost vitality, flattening out and whitening at the edges; next day nearly all had succumbed and the marked sprays were carried off to watch further developments; the leaves touched by the kerosene were easily distinguished, and in each case every egg on every leaf which had been touched by the kerosene first became depressed in the center, then loosened and white around the edges, and finally dried up, leaving only a small, glistening spot on the leaf; on leaves which the emulsion had not touched the eggs underwent no change whatever. Early in October (5th to 7th) I again examined the space treated; the vines had all recovered from the damage done by the larvæ and were promising well for

next season, and the most careful examination discovered but a very few eggs.

RECOMMENDATIONS.

Despite the success attending the use of some of the above insecticides, the damage done by the larva of this insect this season was immense—much more extensive in New Jersey than on Cape Cod, but sufficiently great even there. One of Dr. Brakeley's bogs, which for a fair crop should produce 1,500 bushels and has yielded 2,000, yielded this year less than 200 bushels; one 40-acre bog was almost entirely eaten up, and bogs of excellent vines, which easily produce 200 bushels to the acre, this season yielded but 40 to 50 bushels; only a few bogs were exempt, and the damage done amounted to many thousands of dollars. Many of the growers are becoming disheartened because, though they kill millions of larvæ, yet they still lose their crops. The difficulty is not with the means employed but with the *time* at which they are applied; *the greatest damage is done by the second brood of larvæ in the first two or three days of their life*, because then, before spinning up leaves, they eat into the buds, flowers, and young berries, a single larva in one day sometimes destroying two or three berries or blossoms and being then of a size so small as to be scarcely perceived; their appearance is noted when they begin to spin up the leaves and vines, and war is waged against them, but it is then too late, the greatest damage is done, and growers wonder why so few berries set. To be successful in saving a crop the war *must* be vigorously carried on against the first brood and against the imagines resulting therefrom. From the observations made and recorded above, and having followed Dr. Brakeley's efforts pretty closely during the past year, as well as from the experiences of others reported to me, I advise the following course as most likely to be successful:

The water, if used as first proposed, *i. e.*, reflowing when the larvæ begin to appear, will afford a nearly complete remedy, but even then the surviving members of the first brood must be attacked, for a single female produces from 20 to 25 eggs, and a few hundred escaped larvæ form the nucleus of a destructive second brood. Where the water cannot be so used, it should be held very late, and drawn off gradually, the object being to raise it to as high a temperature as possible, in order to hasten the development of the larva and destroy it in embryo. When the water is off, the vines should be daily examined, so as to note the first appearance of the larva; the time will vary according to the temperature of the air, as well as that of the water which had covered them. In from three to ten days the larvæ will be all hatched; at first they will burrow in the leaf, and then ascend to the tip, and their presence can then be readily noted by the fact that the under side of the leaves can be seen; the top will be found drawn together, and the larva inside; a little experience will enable any one to tell at a glance; as be-

fore stated, they do little injury now, and the danger seems small. One gentleman informed me that there were only a few larvæ on his bog, and he was rather sorry, as there were not enough to experiment with; I visited his bog a day or two afterward and found larvæ pretty evenly distributed over the bog, but doing no great damage. Some time afterward they had all disappeared, and the gentleman was jubilant. He was correct; they had gone—into the pupa state. The moths emerged, and in due time the second brood of larvæ. I did not thereafter hear any complaint of lack of insects to experiment with.

To return. It is at this time that they must be attacked, and best of all with kerosene; this will penetrate through and saturate the leaves, and, if liberally and carefully applied, will kill by far the greater part of the larvæ. The kerosene emulsion should be made with two parts kerosene to one part sour milk, and churned with a force pump; the "aquapult" or "Lewis" will answer. If the milk is heated and the vessel containing the kerosene warmed, ten or twelve minutes, and sometimes less, of churning will suffice to complete the emulsifying process, and the result will be a soft butter which will mix perfectly with water; it should be dissolved with a small amount of water, and then any desired quantity may be added; the most effective proportion for this insect at this stage is ten parts of water to one part of the emulsion. This will not hurt the vines, and should be applied thoroughly, with a syringe or a pump with a sprinkler attachment, if possible. A second application a week later might be advisable to reach any larvæ that had afterwards hatched or previously escaped. If the water has been drawn off gradually the larvæ will continue to hatch for as many days as the water occupied in receding, and the same number of days is gained in combating them.

Another plan would be not to await the hatching of the larvæ, but immediately after drawing the water and ascertaining the presence of living eggs, to apply Paris green mixed with cheap rye flour, while the vines are wet with dew or rain, and thus poison the food the young larvæ will be compelled to subsist on. No danger of poisoning the berries is to be apprehended at this stage, but perhaps the former plan is as certain in results; it is entirely without danger, and therefore preferable. A few larvæ will probably escape and pass into the chrysalis state, which they do usually on the ground among the rubbish. It is now necessary to watch for the first appearance of the moths, and as fast as they appear they should be caught with hand-nets; the time will be between the 1st and 15th of June, usually about the 10th. I noticed that the first moths that emerged were males; three evenings I caught specimens, and all were males. Dr. Brakeley had been in the habit of using a rather cumbrous machine mounted on wheels to catch the moths, and the first evening of using this all that I examined of the captures were males. On June 9 I found the first female, and found the same evening male and female *in coitu*. The female I dissected, and found the eggs still immature; later I caught and confined several females, and in all

cases they proved to be impregnated, but none laid eggs until the second day, and on examining the vines it was not until four days after the moths first appeared that I succeeded in finding an egg. There are, therefore, certainly two or three days during which, if the moths can be caught, they may be prevented from laying eggs. There was a space of a few rods on one of Dr. Brakeley's bogs on which the moths appeared very abundantly. At first, with the moth-catcher used by him, and which it required two men at least to manage, several hundred were caught in an evening, but so many escaped that I suggested large hand-nets; these were made about 14 inches in diameter, of mosquito-netting doubled, and with handles about six feet in length; three men were armed and sent to the infested place, and each caught several thousand—estimate.

There is only an hour and a half or two hours just before dark when this method can be employed, for during the day the moths do not rise; but just before and during the twilight they are easily disturbed and will readily rise, flying low and slowly, and hovering very much like mosquitos, which, by the by, often made their presence among them unpleasantly prominent. Walking slowly over the bog, hundreds of them are disturbed and rise up before one, and by sweeping with the net from side to side, and just over the vines, the great majority of them can be caught. Two or three evenings will suffice to clear as large a spot as there is force to get over, and if the retreat of the water has been gradual the moths will appear in most abundance a day or two apart at different points, and time to combat them will be gained. It must be borne in mind that every female destroyed in time lessens the second brood by 20 to 25, and may save just that number of berries.

The moths of this brood disappear in about eight days, though stragglers remain much later, and where the water has been gradually withdrawn, as recommended, the broods may lap. After the moths entirely disappear the vines should be closely examined for eggs; if they are found abundant, and the vines are not in blossom or the buds fully formed, a heavy dose of kerosene should be applied, which will destroy most of the eggs. If the buds are fully formed or the vines have begun to blossom it is not advisable to apply kerosene, as it may retard the development or injure the buds or blossoms. If all these measures have been *carefully* taken the second brood will be very light, and will do very little damage, even if not further disturbed; but the fight should not be abandoned here; watch closely for the first appearance of the second brood, which will probably be simultaneous with the blossoming of the vines. As already stated, the insect lives for a few days exposed, eating buds, blossoms, and young berries; its work can be noted by prematurely brown, dried-up blossoms, and the insect should now be attacked either by pyrethrum or Paris green, preferably the former. If pyrethrum be used it should be mixed with two and a half times its weight of poor flour, allowed to stand twenty-four hours in a close vessel, and liberally applied when the vines are dry. It is now compara-

tively easy to reach the larva, and nothing acts more rapidly and certainly than pyrethrum. If Paris green be used it should be used in solution and applied with a pump or syringe with sprinkler attachment; the "aquapult" is excellent for that purpose, and the "Whitman" answers every demand. Two or even three applications may be necessary to follow up the constantly hatching worms, but the result will repay for the labor expended. Should, by some combination of misfortunes, all these methods have proved vain, and the insect be still in force, I would recommend repeated heavy doses of the kerosene mixture (1 to 10), which will destroy them, though it may somewhat damage the crop; should, after all, moths appear in any number it would be good policy, after picking, and a few days before putting on the water, to apply kerosene to the vines for the purpose of destroying the eggs.

It may be objected that all this requires a great deal of labor and considerable expense; true as to the former, for it requires constant vigilance and the prompt application of the remedies from the time the water is first drawn to the time when it is again put on, yet if the work is carefully and conscientiously done early in the season, little indeed will remain to be done after the first brood has passed away, because it is utterly impossible that many can survive so vigorous a campaign as that I have mapped out; and as to expense, a dollar an acre will pay for the kerosene mixture. Paris green costs but a trifle, and but a very small quantity is required, while pyrethrum costs 25 to 30 cents per pound at wholesale, and can be mixed with two and a half or three times its bulk of cheap rye flour. Nor will it be necessary to carry on so vigorous a campaign for many years, as the insects will become so scarce that it will require only a very small expenditure of time and money to keep them in thorough subjection, while the increased crops will repay all labor or expense incurred.

I have given no place to tobacco or hellebore in the above campaign, because they are more expensive and, in my opinion, less effective than the preparations above recommended.

One more method I find in my notes as having been successfully tried, easy and simple enough in appearance, but which I hesitate to recommend, because I did not myself see it used, *i. e.*, simply with a kitchen broom to sweep off the tops of the vines. It is gravely asserted that this has been done, and a bog thereby cleared of larvæ; that there were no larvæ on the bog I can certify, because I saw it. Whether there ever were any, or whether the sweeping destroyed them, I will not venture to say; I leave it to be tried by others.

TERAS OXYCOCCANA* Pack.

This insect is not found at all in Massachusetts, so far as I have been able to ascertain, but is abundant everywhere in New Jersey. The species is rather interesting and anomalous in that it has two very distinct forms—a gray winter form and a yellow summer form. This

* *Tortrix vacciniivorana* Pack.; *T. malivorana* Le B.; *T. cinderella* Riley.

dimorphism is unusual in the family, and though some time since recorded by Professor Riley, has not been accepted by Professor Fernald. Dr. Brakeley had several years ago reached that conclusion. The gray moth is called by Packard "the Glistening cranberry moth," and described as follows:

> The body is of a dark slate color, and the palpi, which are large and project well beyond the head, are of the same color, with a few bright reddish scales at the end of the second joint. The tuft of hair on the abdomen is much paler than the rest of the body and of the same color as the legs and the hind wings, being of a glistening gray color. The fore wings are of a uniform reddish brown color, with a peculiar glistening or greasy hue. The red tint is due to scattered, bright red scales. There are no other spots or markings on the wing, and the fringe is mottled with red and gray scales as on the wings. On the hind wings the fringe is long, silky, glossy, grayish white. Beneath, the fore wings are pale gray, the hind wings being paler than the fore wings. Length of the body 0.25, expanse of the wing 0.64 of an inch. It may be readily known by the peculiar, shining, greasy look, and by the rich red scales scattered over the plain, unadorned fore wings.

Dr. Packard records his specimen as having been found in October, and the description shows it to have been a fresh specimen, and judging from the size, probably a female. Of those collected by me, the females are, as a rule, considerably larger than the males, though there are large males and small females. After a few days the moths largely lose their red scales, which rub off very easily, and they appear then of a uniform gray slate color.

These insects, emerging from the chrysalis in October—in my experience, on the 9th and after—pass the winter in this stage, seeking shelter in crevices, outhouses, and rubbish heaps. Dr. Brakeley informs me that he has often seen them in his cranberry house, and on bright, sunny days in winter flying at the edge of woods. In the spring, about the middle of April and to the first of May, they deposit their eggs and disappear. After the beginning of May they are rarely seen. By the 15th of May, or a few days before, the eggs hatch and the larva commences its career precisely as does the *Anchylopera*, except that it does not first burrow into the leaf. Some collected by me changed to pupæ May 24, and transformed into moths June 4; these moths were smaller in size than the gray specimens and entirely different in color, being yellow, with ochreous mottlings, but no distinct markings on the fore wings, and silky white on the hind wings and body. On fresh specimens the ochreous or reddish scales are dense, and give the insect a deeper color; flown specimens lack these scales and appear uniformly yellow. The sexes do not differ in size, and none expand more, and many less than 0.5 inches. None of these insects showed the slightest tendency to the slate-colored form. The second brood of larvæ appears toward the end of June or early in July, and has precisely the same blossom- and berry-eating habit as the *Anchylopera*; in fact, I found that the berry-eating larvæ were mostly those of this species. They continue this until nearly half grown, and then spin up sprays and leaves,

as does the *Anchylopera*. Toward the end of July the larvæ pupate, either in their habitations or on a leaf close by—never on the ground. The second brood of moths emerges in August (18th to 23d), and the moths of this also are uniformly yellow; one specimen only which I found had the hind wings and body dusky, but this escaped through the meshes of my net while I was examining it. These moths oviposit in the early part of September and produce larvæ about the 12th. The chrysalis is formed late in September or the first of October, and the moths emerge about the 9th or a little later. This brood of moths is uniformly gray. I did not meet with a single exception, and that it is the result of the eggs laid by the yellow form I am perfectly positive, for not only were there no gray moths on the bog to produce them, but I watched the yellow forms oviposit, obtained some eggs from females in confinement, and sent them to Washington to be reared, and Professor Riley informs me that gray individuals were obtained from them.* The moths continued to emerge and were flying on the bog when the water was put on.

The egg of this species is precisely like that of the *Anchylopera* in form and color, but is very slightly larger; it is laid on the under side of a leaf, as in that species, and at about the same time, so that practically it is impossible to distinguish the two; the larva also much resembles that

*In the "General Index and Supplement to the nine reports on the Insects of Missouri," 1881, in speaking of *Tortrix cinderella* Riley, we remarked as follows (pp. 82–83):

"From specimens reared from cranberry-feeding larvæ received from Mr. John H. Brakeley, of Bordentown, N. J., I am satisfied that this is the same species briefly characterized by Packard in the first edition of his *Guide* (p. 334) as *Tortrix oxycoccana*, and that *T. malivorana* LeBaron (my Rep. IV, p. 47) is but a dimorphic, orange form, subsequently described by Packard as *T. vacciniivorana* (Hayden's Report of the U. S. Geol. and Geogr. Survey of the Territories, 1878, p. 522). The orange and ash-gray specimens are thus bred both from Apple and Cranberry. I have reared both forms from Cranberry and from Apple, and they are undistinguishable in the larva and pupa states. The gray form is often more or less suffused with orange scales and the orange form less frequently with gray scales. This is the most remarkable case of dimorphism with which I am familiar in the family, and points strongly to the important bearing of biological facts on a true classification. The dimorphic coloring is not sexual, but occurs in both sexes. The eggs of this species are very flat, circular, and translucent, with a diameter of 0.7^{mm}, and are laid singly on the under side of the leaf near the mid rib. The species belongs to the genus *Teras*, and as Packard's specific name *oxycoccana* has priority, the insect should be known as *Teras oxycoccana*, Pack. The insect, according to Mr. Brakeley, who gives an account of it in the Report of the Seventh Annual Convention of the New Jersey Cranberry Association (1879, p. 7), commonly affects, also, the high-bush whortleberry. The gray form of the moth is most frequent in autumn."

Prof. C. H. Fernald, in his "Synonymical catalogue of the described Tortricidæ of North America, north of Mexico," 1882, as stated by Mr. Smith, still retains the four insects as distinct species, and thus doubts the correctness of our conclusions. We therefore took pains to put the question to so full a test as to leave no reason for doubt. Mr. Smith's experience in the field, as above shown, is confirmatory; but from material which he sent on to Washington, we not only actually bred the orange form from the first brood of larvæ received in May and produced from the hybernating slate-colored form, but also the slate-colored form from larvæ hatched from eggs laid by the orange form. Over two hundred specimens, reared from larvæ received in August, and produced by the second brood of orange moths are all referable to the slate-colored form. In fact all the moths which issued after September 23 were of this form, though there was but a difference of five days between the issuing of the last yellow and the first gray specimens, the latter continuing to issue through October. Many of the gray specimens, especially those which first appear, are so suffused with orange or reddish scales as to appear somewhat intermediate between the two extremes, but there are none which are not at once referable to the gray form. It is in fact an interesting case of seasonal dimorphism, and how far it is influenced by temperature, future experiment, which we hope to make, will determine.—*C. V. R.*

of the *Anchylopera* in habit and general appearance; the head and neck, however, are honey-yellow instead of black; the body is of a somewhat paler green, and the larva when full-grown is larger—nearly half an inch in length. The head is nearly as wide as the first segment; and the body tapers gradually to the tail, and is furnished with fine, sparse, pale hairs arising from prominent tubercles; the four dorsal tubercles are arranged in a trapezoid with a deep crease between the anterior and posterior pair; the anterior three pairs of feet are tipped with black. On each side of the base of the head is a lateral, S-shaped, blackish-brown, linear band, the upper part of the S terminating on the top of the occiput, the line being most distinct on the side of the head. The ocelli are black. The pupa is brown, rather slender, and has the head prolonged into a large tubercle surmounted by a large, round and roughened knob; there is an angular projection on each side of the head, forming a shoulder to it. "The wing-covers reach to the end of the third abdominal ring, while the antennæ reach to the end of the second pair of feet, which are parallel to the end of the second abdominal ring. There are two rows of teeth on the upper side of the abdominal rings; they are obsolete beneath, the posterior row being indicated by two remote, minute tubercles." It is about two-fifths of an inch long. There is no appreciable difference in size between the larva of the gray or winter form and that of the summer form, but the pupa of the latter is rather smaller.

ENEMIES.

Unlike the *Anchylopera*, which appears free from insect enemies, this insect is preyed upon by two parasites: a dipterous larva belonging to a species of Tachinid and the larva of an Ichneumonid.*

These parasites I have found in the second brood only; all my larvæ of the first and third broods completed their changes, while those of the second brood were almost all infested with parasites, and these I apprehend will do much to prevent this species from becoming as plentiful as the *Anchylopera*.

REMEDIES.

A bog that can be completely flowed need never suffer much from this insect. All that is necessary is to keep the water on in the spring until after May 1. By that time the surviving moths will either have perished without depositing eggs at all, or they will be compelled to deposit them on the apple trees or whortleberry bushes; the latter being probably their original food before the abundance of cranberries enticed them to the bogs and led to their rapid increase. This remedy has

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* None of the specimens of the Tachinid bred by Mr. Smith had the wings developed, and all were otherwise so shriveled and imperfect that determination is impossible. The Ichneumonid is *Macrocentrus delicatus* Cr., figured in our Fifth report on the insects of Missouri as parasitic on the Apple Worm (*Carpocapsa pomonella*). It is an interesting fact, as bearing on the unity of habit in the same genus, that we have likewise reared *Macrocentrus* from two other Tortricids, viz., *Grapholitha caryæana* Fitch and *Tortrix paludana* Rob.——*C. V. R.*

quick and certain in its action where it touches the larva, and, liberally applied, it would undoubtedly destroy the vast majority of them. Where the larvæ are scattered singly over the bog they usually escape notice entirely and do no appreciable damage.

An insect common to the Cape and New Jersey, though much more destructive on the Cape, is

THE CRANBERRY FRUIT WORM.*

The moth producing this pest expands rather more than half an inch, has narrow fore wings, and broad, somewhat triangular, hind wings; the head is broad, the eyes large and black, and the palpi project well beyond the head. The color of the body and secondaries is a rather pale gray, with a slight metallic glisten, more pronounced on the thorax, where white metallic scales are intermixed. The fore wings are rather darker gray, with a more decided metallic luster; along the costa is a snowy white margin, most distinct and widest at the middle of the wing, narrowing and sprinkled with gray scales at the base and apex. There is a darker, transverse shade very near the base; a more distinct, darker, transverse band just inside the middle, and an oblique and less distinct shade from the apex to the inner margin, more diffuse near the middle of the wing. Above the center of the wing, at the outer third, is a rather long, paler spot, constricted at the middle, at each end of which is a blackish spot. Beneath, the wings are of a uniform glistening gray color, darker on the fore wings. The fringes on both wings are concolorous. This insect appears on the bogs late in June and early in July, with the first appearance of berries; it is shy, flies rapidly, and is not easily captured. When and where the egg is deposited is not yet known, but probably on the young berry. The young berry-worm appears as soon as the berries are well set, eats out the center only, and then migrates to another berry. The vacated berry turns red and eventually shrivels up and drops. The larva, on entering the new berry, carefully spins up the aperture made to effect an entry with a dense web of fine, white silk, so that it is sometimes difficult to see where the hole was made. In this berry it becomes half-grown, and, working out, leaves a jagged opening, and again enters a new berry; the berries are by this time well grown, and sometimes the larva reaches its full size in this third berry. The place of entry is as carefully closed as in the previous case, and soon the berry begins to show a red color, denoting to the practised eye the presence of the enemy, but to the uninitiated appearing only to be nicely ripening. Where the larva does not complete its growth in this berry, it migrates to another, this time *not* closing the port of entry. The berries are by this time nearly fully grown, and about the latter part of September or the beginning of October the worms are fully

* This is a Phycid belonging apparently to *Myelois*, but as only one poor and damaged specimen was obtained, we cannot now properly characterize it.—*C. V. R.*

grown, leave the berry, and go into the pupa state. Dr. Brakeley, who has raised the insect, and from whom I obtained a part of the above history, says that the larva pupates in the ground, and the moth emerges next spring. The larvæ appear to differ greatly in rapidity of growth, as in early August, when I examined many hundreds at Cape Cod, all sizes were represented, from the mite but a line or two in length to the nearly full-grown larva half an inch in length and completely filling the interior of the berry. The full-grown larva is half an inch or a little more in length, of a bright green color, often with a reddish tinge, most prominent on the dorsum. The head is narrower than the first segment, and is of a paler, more yellowish color, except the mouth, which is brown; the segments are transversely wrinkled, and are clothed with a few sparse and rather long hairs. As a whole, the insect is more compactly built than either of the preceding, and is of the same thickness throughout.

The damage done by this insect in the cranberry bogs of Cape Cod this season is very large. In New Jersey scarcely a specimen could be found, and nowhere was it plenty. On August 7 to 11, I visited the Cape Cod bogs. Scarcely one but was infested by this insect, and many were so badly attacked that not 20 per cent. of the berries were sound; in one bog near Hyannis, which had escaped the fire-worm, the berries on August 8 were 90 per cent. red, and apparently ready to gather; closer examination developed a berry worm in almost every berry, and there was every likelihood of the whole crop being eaten, as the worms were scarcely half-grown.

REMEDIES.

An Ichneumon fly is said to prey on this worm, but I did not succeed in breeding it, and it cannot apparently be depended upon to keep the species within limits. I could not find that any remedies against this insect had been successfully used. Tobacco had been tried, but without success, and the same result attended the use of Paris green. Flowing has been tried, but where the water has been left on long enough to destroy the insects, it has also destroyed the berries. The fact is that it is a matter of great difficulty, if not absolute impossibility, to reach this insect in the larva state. The fact that it lives in the berry, and carefully closes up the place of entrance, excludes poisons which kill by touch or by being eaten, because the larva never comes into contact with them. Flowing is an incomplete remedy for the same reason. It is possible for the larva to remain submerged for a week or more without being in the least discommoded, and so long a submergence during August or September would infallibly ruin the crop, although it might thereby also destroy the insect. It is probable that at some portion of its career this insect can be successfully combated, but as most of my investigations this season were made in New Jersey, where this insect was not to be found, I was not able to ascertain its complete history, and can therefore suggest no remedy.

THE BROAD-WINGED LEAF-HOPPER.

(*Amphiscepa bivittata* Say.)

This little insect, while found on every bog, does little injury. It feeds on the juices of the plant, and did it ever appear in large numbers it might become injurious. The insect is about a quarter of an inch long, and the expanded wings measure half an inch. The head is red-brown, with a greenish vertex; the thorax is of a deep brown-red; the body is yellow, and the hind wings are transparent; the fore wings are bright green, except the inner margin, which is bright carmine-red. In shape the wings are broad, semicircular, and when the insect is at rest the folded wings resemble an undersized leaf. The hind legs are formed for leaping, and the insect is very active, using its legs and wings to good advantage in its changes of locality. Should it ever become injurious, the use of hand-nets and of the kerosene emulsion would be indicated.

THE CRANBERRY-TIP WORM.

Early in July I noticed in one small spot on a bog an occasional vine which had failed to grow, and had a bud apparently just ready to open. Examining some of these, I found the tip eaten off and the outer leaf only covering the destroyed tip; further search developed a specimen or two of a small, red, apodous grub about half a line (0.04 inch) in length, tapering toward each end, but most toward the head. The specimens were evidently weak and did not enter the pupa state. A few pupæ were afterwards found close to the base of the outer leaf of the terminal bud and in a small cavity formed for it; they were enveloped in a dense, white cocoon of silk, and from one of these the imago emerged toward the end of August, during my absence from home; from the remains, the insect seems to be a minute midge, of a clay-yellow color, with long legs and antennæ. I could find none on the bogs, and up to October 10 there were no traces of larvæ in the terminal buds of the vines. In small spots this insect was apparently quite plentiful, judging from the destroyed tips, but none of the growers seem to have noticed it, and it has evidently never been very injurious. Should it become abundant at any time, the kerosene mixture will prove a complete remedy for it.

LOCUSTS AND CRICKETS.

Ten species of locusts and a cricket (*Gryllus neglectus* Scudd.) were found on the bogs, and evidently do considerable damage. The locusts are *Acridium alutaceum* (?) Harr., *Caloptenus bivittatus* Scudd., *Œdipoda collaris* Scudd., *Œdipoda maritima* Uhl., *Tomonotus sulphureus* Sauss., *Œdipoda æqualis* (?) Scudd., *Œdipoda eucerata* Harr., *Stenobothrus maculipennis* Scudd. var., *Caloptenus* sp. near *femur-rubrum* Deg., and *Caloptenus punctulatus* (?) Uhl.

They often grow to an enormous size compared with their usual development. They do not find their food exclusively on the bogs, but when nearly full-grown they have the habit of biting pieces out of the cranberries, which, of course, soon wither and die. They seldom eat an entire berry, but usually eat out the seeds and then leave it. The cricket has the same habit. Probably all the species of locusts found in the various localities find their way on the bogs, and none live exclusively in them, for I found the same species that were common on the bog were also common in the woods and fields everywhere in the vicinity. A cheap and very effective remedy against the depredations of these insects is a flock of turkeys. Dr. Brakeley has between 50 and 100, which day by day journey to the bogs and cross and recross them in every direction, coming home each evening with crops distended to their fullest extent. The difference between his bogs and those of his neighbors, in the matter of locusts, is marked; only an occasional one will fly up before you on his bogs, while on the other bogs visited by me locusts started up everywhere by the dozen. Both pyrethrum and kerosene kill the locusts when they come into contact with them, but turkeys constitute by far the best and easiest remedy to apply.

THE CHAIN-SPOTTED GEOMETER.

(*Zerene catenaria* Gn.)

On some bogs of Cape Cod an insect locally known as the yellow span worm sometimes becomes somewhat injurious. The parent of the larva is known as the "chain-spotted geometer," and is pure white, except for the front of the head and the shoulder tippets, which are yellow. The fore wings have a narrow, zigzag black line on the inner third of the wing, a distinct, black discal dot and a scalloped black line half-way between the discal dot and outer edge. The hind wings have a black discal dot and a single black line, often more or less broken at the outer third of the wing. It expands nearly 2 inches.

The larva is 1½ inches or more in length, equally thick throughout, of a bright sulphur-yellow color with paler and black markings. It is readily recognized and easily seen on the bogs; it is found in moderate numbers on the various bushes growing at the edge of the bogs, and appears a general feeder. The uniform testimony is that the young larvæ are never found on the bog, but when they attain the length of an inch they sometimes leave their natural food-plants and invade the bog, eating rapidly and doing considerable damage.

The remedy for this lies in prevention, and is easy: Clear the ditches surrounding your bog, have them at least two feet wide and half full of water, and cut off the brush for a few feet from the edge of the bog. The remedy is complete.

THE RED-STRIPED CRANBERRY WORM.

In the latter part of September and early part of October I found on a bog in New Jersey a few specimens of a larva described by Dr. Packard under the above name; the specimens agree very well with his description, which is substantially as follows:

The body is long and slender, nearly three-fifths of an inch in length, slightly tapering to the head, but more decidedly toward the tail; general color pale livid green with six longitudinal, pale reddish lines, broken and irregular toward the head, but more distinct and wider toward the tail, so that the body looks darker and rather more reddish posteriorly. The head is pale yellowish with a few long hairs; the mandibles are reddish, darker at the tip. Ocelli blackish. Prothorax unusually long, nearly as long as the head, and entirely without markings; it is slightly wider than the head, but narrower than the succeeding segment. On the front edge of the second and third rings is a transverse row of six black, minute warts giving rise to a hair, and a seventh one low down in the middle of the side. On the abdominal segments there are four dorsal black warts, the two anterior nearer together than the posterior, though not forming a decided trapezoid; on the side of the ring is another black wart in line with the two anterior dorsal ones and giving rise to a rather stout hair. Around the edge of the supra-anal plate is a row of four black warts and two median, dorsal, smaller warts. Beneath, livid greenish, the three segments between the last pairs of feet with each a transverse, straight row of minute, black warts.

The habits of this caterpillar are much like those of the *Teras* and of the *Anchylopera;* like them it draws together the leaves of a spray, but unlike them it often severs the leaves and forms a complete tube of silk with an outer covering of leaves; this tube is always open at each end, and the larva, which is very active, slips out at the least disturbance. It was found on a single spot only, and in small numbers, and this spot was just the one part of the bog not flowed during the winter. At date (October 22), the larvæ have not yet pupated, while the bogs are either entirely or nearly covered with water. The remedy is indicated by the length of larval life, and it consists simply in flowing the bog as early in the fall as it can be safely done and before the larva changes to the pupa stage. The fact that I found this larva in the only part of the bog not flowed, and not elsewhere, is significant and points to the best remedy.

Some other insects have been recorded as feeding on, or in some way injurious to, the cranberries, but these are all observed by me during the past season. Some of them may be found in Massachusetts or elsewhere, on bogs that I did not get to see, but I heard no complaints of other insects from localities which I have visited, except that Mr. Makepeace, of Hyannis, Mass., who has probably the largest acreage of cranberries under his care of any one man in Massachusetts, complains of a root

worm, and of an insect eating the runners of the vines. The roots of the cranberries are exceedingly numerous and fine, and it seems scarcely possible that an insect living in the roots, as it is claimed this does, should exist and do serious injury. Captain Ames, of Cotuit, has heard of this insect, and showed me places on his bog said to be caused by it. Careful examination revealed nothing. The insect said to injure the runners leaves traces of its work, but the insect itself seems very difficult to find. A cranberry plant will send off runners in every direction; the runners send out uprights which bear the fruit; the runners lie on the surface of the ground, and when a bog is resanded, or before, take root at intervals, though sometimes a runner will maintain six or more uprights from the main root. It is the bark of these runners that is eaten off at the under side; never much, but a little bite here and another little bite there; the runner loses vitality, the uprights die, and the infested space becomes brown and dry. This gradually spreads, though as yet no very great damage has been done. I examined several of these spaces and on every one of them I found the same appearance, *i. e.*, dead vines, and on the runners a few small patches deprived of bark; this, Captain Ames says, is sufficient to destroy a vine. One or two of these barkings appearing tolerably fresh, I made a close search for insects without any success; the only living thing found was a centiped. Captain Ames says that he has seen the depredator, and he is the only one whom I could find that had. He says it is an active, brown insect with many legs and some hair-like appendages at the sides. He says he has seen them early in the season and again late in the season, but never at the time I saw him, *i. e.*, August 9. I requested him to look out for the next appearance of the insect and to send me specimens, but I have not thus far heard from him, though he promised to comply with my request. The insect has received the name of "girdle worm" among Cape Cod growers.

I have found a few other insects on the bogs, some *Hemiptera homoptera* and some *Hemiptera heteroptera*, but they are not cranberry feeders. They live on the weeds and grasses found on neglected bogs, and the more neglected a bog is, the greater the variety and number of small insects that are found on it. I have no doubt but that most of these insects do occasionally attack the cranberry, but I am equally certain that, except the mosquito, they would not be on the bog were the weeds not there.

HOP INSECTS.

The hop crop this year was greatly damaged by insects, principally the Hop Aphis, ably seconded by the "Grub," and materially assisted by a number of other pests. Herkimer in early summer, Waterville later on, and then Cooperstown furnished the centers of investigation. At Athens I examined a yard that had formerly suffered much from insect attack, and the yards in the vicinity of Deansville and Oriskany Falls were visited, so that I might be able to detect local pests, should there be any unusually abundant. To Mr. Frank Cutter, editor of the *Waterville Times*, I owe thanks for the courtesy, assistance, and information afforded me; to Mr. Lawrence, manager of the Hop Extract works at Waterville, I am indebted for information and free permission to dig, delve, and otherwise amuse myself in his hop yard, and to sacrifice such numbers of vines as the necessities of the case might demand. At Herkimer, Mr. George W. Pine assisted me in making a first acquaintance with the "Grub." At Cooperstown, Mr. J. F. Clark gave me great aid in my researches on the Aphis. To Mr. Ira C. Jenks, of Deansville, I tender my thanks for aid on the same subject, and to the growers everywhere I owe gratitude for such aid and information as they were able to give me.

One of the insects most destructive to the hop vine, and which threatened at one time to entirely destroy the yards in certain districts is—

THE HOP GRUB.

(Larva of *Hydræcia immanis* Gn.)

This insect measures from 1¼ to 2 inches in expanse of wing, is stoutly built, of a yellowish brown or rather pale rust color; the middle portion of the fore wing is darkest, and incloses two large, somewhat kidney-shaped, paler spots; the outer portion of the wing is paler; the hind wings are rather more yellowish, uniformly colored, and not so thickly covered with scales as are the fore wings.

Of this moth a few specimens appear in the fall, but the majority appear in spring, from the beginning to the end of May or later, according to the season.

The egg is deposited by the female upon the tip of the hop vine when it begins to climb, and is, as I am informed by Mr. Fees and Mr. Jenks, about the size of a pin head, globular in form, and of a yellowish-green color. The egg hatches in a few days and produces a minute, slender, greenish larva, spotted with black, which immediately burrows into the vine just below the tip, and spends a part of its life in the vine at this point.

The vine soon shows the effect of the insect's work; instead of pointing upward, embracing the pole readily and growing rapidly, the tip points downward, will not climb, and almost entirely ceases growing. This appearance is called by growers a "muffle head," and such "muffle

heads," I am informed by growers, were quite common this spring. The heads had been opened and the larva detected, but the parentage was almost universally attributed to a "green fly" mentioned, but not more nearly described in several agricultural papers. This fly, as nearly as I can make out from the description of growers, is a *Syrphus*, and probably the parent of the larva found afterward destroying the hop aphis. At any rate, it is not the parent of this "tip worm," as the insect has been called. Not all "muffle heads" are caused by this larva, however, as will be hereafter pointed out.

When the insect attains a length of about half an inch or slightly less, it leaves the tip, drops to the ground, and, entering the stem at the surface of the vine, feeds upward, interrupting the growth of the vine and lessening its vitality; the larva now changes color, and becomes a dirty white with a strong, deep reddish tint, apparently proceeding from beneath the surface of the skin, and with numerous black spots. As the vine grows, it becomes hollow and hardens, and the more rapidly as the free flow of sap is interrupted. The larva, now about an inch in length, and still slender, burrows downward to the base of the vine at its junction with the old stock, and, eating its way out, completes its growth as a subterranean worker; it is in this state that it is best and most widely known as the hop "grub," and the ravages caused by it are most noted.

The journey from the stem to the ground is made in the beginning of June, and by the 21st of June, while I found many larvæ in the ground about the roots, none were found in the stems, though traces of their work were everywhere abundant.

The larva now is mainly a sap feeder. It eats a small hole into the side of the stem just below the surface and just above the old root, and grows fat rapidly on the juices that should nourish the plant. As the sap seeks courses to enable it to reach the upper part of the vine unmolested, the grub enlarges its opening until he sometimes severs it entirely from the parent root, and the vine dies. In other cases it is left barely attached to the root, and continues a precarious existence, yielding few or no hops. Occasionally an exceptionally healthy vine will entirely recover from a serious attack of "grub." By the middle or the 20th of July the larvæ are full-grown and ready to enter the pupa state. They are now about 2 inches in length, fleshy, unwieldy, and very slow in their movements; they are of a dirty white color, speckled with fine, brownish, elevated tubercles, each furnished with a single stout hair; the head is brownish and corneous, as is also the top of the first segment.

About the 20th of July the pupa is formed in a rude cell close to the roots of the plant, upon which, during its larval existence, the insect fed. The pupa is an inch or slightly more in length, stout, cylindro-conic, and of a deep brown or blackish color. In this condition it passes the winter, though, as before remarked, a few specimens appear in the fall. Whether these latter hibernate or whether they perish, I have not been able to ascertain, though the latter seems the more likely.

This insect is not equally common in all years nor in all localities. It will sometimes be plenty and greatly damage one yard, while the closely adjoining yard is untouched. As a rule, also, the outskirts of the yards are the greatest sufferers, while the interior yards escape. The habit of the moth seems to be to lay its eggs on all available places, and often every shoot from the roots, amounting to fifteen or more, will turn out "muffle heads," and consequently useless. As many as twenty larvæ have been found in a single hill, while I myself have found thirteen specimens. Where nothing is done to check them they do considerable damage, and may, and indeed have destroyed entire yards.

REMEDIES.

The remedies to be recommended for the destruction of these insects are simple, cheap, and efficient.

First. Cultivate skunks. They are an invaluable aid, require no pay, no care, and ask only to be let alone and not interfered with in their work. In every yard in which the grubs were common, and where there were any convenient hiding and breeding places for skunks near by, traces of their presence could be seen in the tunnel made by the sharp snout of the animal in its search for the fat larvæ; for it is not until the larva is full grown or has changed into a pupa that the skunk cares to hunt it up, but then he is a thorough worker, and where the traces of skunk were seen on a hill it was very seldom that a larva or pupa could be found. It was thus that, relying on the large numbers of young larvæ found in early spring, I found in July, when I went to gather mature forms and pupæ, that everywhere the skunks had preceded me, so that it was with some difficulty I secured a few specimens, and later, when I requested a grower to send me a few, I received answer that none could be found. Of course some will escape and transform, unless reached by some other means, and I would recommend—

Second. Search for and destruction of the pupæ in early spring. This can be done without much additional labor when grubbing and cleaning the roots. Most growers assured me, when I had described or shown them the pupa, that they had seen the same thing every spring when grubbing; but had not connected them with the "grub," and had turned them under again when re-covering the roots. Instead of re-covering, destroy each pupa seen, and keep a sharp lookout for them in turning over the earth. A little experience will render the pupa readily recognizable.

Third. Destroy them when tip-worms and in the "muffle heads." The "muffle heads" begin to appear when the vines have begun to climb, and when growers are beginning to tie. In selecting the vines to be trained on the pole be careful there are no "muffle heads," and wherever one is observed pick it off, and by compression between the fingers destroy the larva in the tip. As all the vines have to be handled in selecting, very little time will be lost in picking off infested heads, and by going through the yards carefully every second day and picking off

"muffle heads" as they appear, a yard of considerable extent can be kept clear with little trouble; the larvæ do not appear to remain in the head more than a week or ten days, and that during the time when the vines are low, the tips within plain sight and easily reached.

Fourth. If none of the preceding methods have succeeded in entirely ridding the yard of grubs, and as a matter of precaution, even if no damage from grubs is observed, it is good policy to expose the roots for a few days; but little trouble is necessary to do this, for before hilling the roots are but scarcely covered, and only enough earth to bare the junction of the growing vine with the old root need be removed. This should be done early in June, when the larvæ have left the inside of the vines. They will not eat above ground, and will take to the old roots, to which they do little or no harm. Five or six days will be a sufficiently long time to expose the roots; then apply a handful of a mixture of coal and wood ashes, or ammoniated phosphate, and hill high. Both of these substances have been used as remedies against the grub, and both successfully by some and unsuccessfully by others; the differences are unreconcilable by the fact that in neither case was it the application of the ashes or phosphates that destroyed or kept off the grub, but the treatment adopted in conjunction with these applications. If, in addition to the application of any desired fertilizer, the vines are hilled, and the hills made high, the vines will throw off rootlets above the main root and be able to derive sustenance from them, whereas when there are no hills, or the hills are low, when the grub does attack the vine it immediately deprives it of a part of the necessary sustenance and impairs its vitality. Both the ashes and phosphate are repugnant to the grub, but not deadly, and it will dare them after a few days to get at its favorite location. Figs. 2, 3, and 4 explain my meaning; the former is from a vine almost eaten off, but still flourishing, being sustained by its rootlets, much longer and more numerous than indicated in the figure, while the two latter are from vines insufficiently hilled, and which were killed by the grubs. The vine represented in Fig. 3 had been slightly bent and partially covered with earth and was attacked by three grubs in as many places.

Fig. 2.

Fig. 3.

Fig. 4.

Parasites I have not found or heard of, but the larva of a Carabid, probably *Calosoma calidum*, is known to feed on the young grubs. A

gentleman in Sangerfield informs me that he several times tried the experiment of placing a grub in the way of the larva, and each time it was set upon and immediately devoured. I found none of these larvæ at Herkimer in June, and on July 22 the grubs had mostly changed to pupæ, while the carabid larva had also disappeared. I could not find a specimen, nor could my informant, though he said they were common enough a few days previous.

In the preceding account, the young grub is said to produce the "muffle head," and this is correct; but not all "muffle heads" are produced by the grubs. My attention was called by several growers to yards where the vines were stunted, the tops imperfect; they refused to climb; the hills were called "slide downs," "foolish hills," or "blighted," and, as a rule, the damage was attributed to the "fly," a little green leaf-hopper hereafter described. Several yards showed this appearance in nearly every hill, while in most yards there were some instances of it. At the Hop Extract works there was a yard, every hill of which was "blighted," and here I carefully examined the vines from root to tip to ascertain whether the trouble was caused by insects. My conclusion is that it is not so caused, because while in some few hills I found the grub or traces of his work, most of the hills were absolutely free from all insect attack sufficient to cause this appearance. The vines are short and bushy, the heads are fuzzy, the vines become wiry, hard, and bony toward the tip, the joints are but an inch or less apart, and the leaves imperfect. The arms thrown out by the vine grow well at first, but in a short time become as bad as the main vine. No crop can be expected from such vines. I soon satisfied myself that nowhere above ground was any insect at work on the plants, and found also that the affected vines were wiry and unhealthy to the parent root, and that the parent root was entirely free from insect attack, but of a more shriveled, unhealthy appearance than in normal hills. I found, too, that this "blight" was universal in low, moist ground; that hill yards were almost entirely free from it, and where it occurred in a hill yard it was in some depression where the water could accumulate; during the spring, rains were frequent and heavy, and the ground was sodden and unfit for working for some time, and early in the season there were several frosts soon after soaking rains.

The conclusion is that the frost nipped the vines in the moist grounds while it had no effect on the hill yards where the drainage was rapid and complete. At all events, whatever be the cause of this "blight" it is *not* attributable to insects. A "muffle head" caused by the grub can be at a glance distinguished from a "blighted" vine by the long joints and otherwise healthy condition of the vine. The "blight" shortens the joints and affects all the arms of the vine, while the "grub" affects only the heads inhabited by it and does not otherwise cause any abnormal appearances.

NOTE.—I have given this insect the name *Hydrœcia immanis* Gn., though on close comparison with the European *H. micacea* Esp. I can

find no difference except in size. Guenée says the larva of *micacea* is of a carneous-gray color and that it lives in sedges. Lederer says the larvæ are pale yellow, with darker tubercles and horny plate on the neck, and live when young in the stems, later on the tuberous roots of *Cacalia*. Sepp figures the larva of *micacea* as of an obscure violet, in the stems of *Rumex*. This range of variation includes the different appearances assumed by our larva in its growth, but for the present, perhaps, the species had better be retained as distinct. *H. obliqua* Harvey, is, however, undoubtedly only a local variation of *immanis;* and as hop-growing in Washington Territory, whence that insect comes, is assuming large dimensions, we may expect soon to hear complaints of damage done there by the "grub."

THE HOP SNOUT-MOTH.

(*Hypena humuli* Harr.)

The larva of a small, obscurely colored and marked moth was found in spring, at Herkimer, in a single low-lying yard. A hill yard close by was entirely free from it, and at Waterville I found no traces of it. The caterpillar is pea-green, speckled with minute black dots giving rise to short hairs, and there are two paler whitish lines on the back and one on each side; it has 14 legs, and when walking bends up the back a little. On June 22 I found a few specimens of the larvæ; they were then about an inch in length and very active, dropping from the leaf the moment they noticed approaching disturbance and making for some place of concealment on reaching the ground. The few specimens I gathered died. On July 14, in the same yard, I saw perhaps half a dozen specimens of about the same size. They did no particular harm, eating holes in some of the lower leaves, but not to a noticeable extent. The larva when full-grown spins a thin, silken cocoon in a folded leaf or in some crevice, changes to a brown chrysalis and soon after comes forth as a moth whose wings measure about an inch or a little more when expanded. The color varies from rust to black brown; they are slightly mottled with paler markings, have an oblique paler dash at the tip, and a scalloped, more or less distinct, pale transverse line beyond the middle of the fore wings. The hind wings are dusky, without evident markings. A peculiar feature of the moth and one by which it can be easily known is the projecting snout, formed by the long, flattened palpi or mouth-feelers which are held close together and projecting horizontally forward. There are said to be two broods, but I did not succeed in finding the larva again later in the season, and to nearly all growers of whom I inquired the insect was entirely unknown. Should it become numerous it can be controlled by taking advantage of its habit of at once dropping to the ground when disturbed; by brushing with a stick up and down the vines the larva will be induced to drop to the ground where a big foot, rightly placed, will prove a complete remedy. It will not take long and need be done but once or twice.

THE COMMA BUTTERFLY.

(*Vanessa comma* Harr.)

The larvæ of this species were quite destructive in some districts, notably about Cooperstown, this spring, but they disappeared early in July. The vines soon recovered, and appeared to suffer no permanent injury.

This larva is the "thorny green worm" of some letters to local newspapers. It is usually of a green color. but varies from almost white to yellowish brown, dusted with a fine, whitish powder in some specimens. The head is furnished with two blackish, branched spines, while the spines with which the body is furnished vary in color with that of the other parts, but are always tipped with black. When fully grown it is between 1½ and 2 inches in length, and then transforms into a chrysalis of a woody brown color, furnished with spines on the body, a nose-like projection in front near the head, and ornamented with golden or silver spots. These chrysalids are known to growers and those engaged in hop-yards as "hop merchants," and according as the color of the metallic spots is golden or silver, so will the price of hops range high or low, so the story goes. The butterfly which emerges from these chrysalids expands from 2 to 2½ inches; upper side tawny orange, fore wings bordered and spotted with black; hind wings shaded with dark brown, with two black spots in the middle, and three more in a transverse row from the front edge and a row of bright orange-colored spots before the hind margin; outer edges of the wings powdered with reddish white; under side marbled with light and dark brown, the hind wings with a silvery comma in the middle.

These insects are usually kept in check by minute parasites, which deposit their eggs in the caterpillar, so that not one in ten ever attains the butterfly state. Still, they occasionally become numerous enough to do considerable damage, and require measures to reduce their numbers. The best of these is hand-picking. The only time they ever prove destructive is in early summer, when the first brood approaches its full size, and at a time when work in the yards and about the vines, trimming, tying, &c., is continually going on, and wherever they are perceived they should be at once picked off and destroyed. They are seldom numerous, but their size and voracity make their work very apparent. As when young they feed, if not in company, yet close together, an entire brood can often be destroyed in a moment, and by a little labor directed to that end a yard can be kept clear of these insects. The second brood does not seem ever to be perceived, and I could not learn that they had ever done any appreciable damage. In fall I found the larvæ few and far between, and the chrysalids I collected were one and all infested with parasites.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* Sm. & Abb.)

This omnivorous insect I found in some numbers on the hop; not sufficiently numerous to attract the attention of growers, but sufficiently abundant to form the nucleus from which future broods may spring; numerous enough to demand notice. The larva, when full-grown, is from 1 to 1¼ inches in length, of a bright yellow color, sparingly clothed at the sides with pale hair. There is a dusky stripe on each side, and a darker or black stripe on the back; the head and two little warts on the ninth and tenth rings are bright coral red; there are two tufts or pencils of long, black hair on the first segment, and a single, similar tuft on the eleventh; the fourth, fifth, sixth, and seventh segments have each a thick brush of short, stout, yellow hair, giving the larva rather an odd but at the same time pretty appearance. When full-grown it spins a cocoon, and transforms into a whitish pupa. The female moth, emerging from the pupa, is wingless, and never moves further than the upper side of the cocoon from which she emerged. The male is winged; the wings expand about 1 inch; are of a deep ash gray, crossed by darker lines. The eggs are laid on the empty cocoon of the female; are covered by a white, frothy matter which soon hardens; and, when laid in the fall, do not hatch until the following spring.

These insects can be easily controlled. The cocoons and egg-masses are attached either to the leaves, vines, or hop poles, or occasionally to fences surrounding the yard. The vines are usually burnt when picking is over, and the egg masses on the vines are thus destroyed; the poles should be examined either when stacked for the winter or when set in the spring, and the adhering egg-masses should be collected and destroyed. Being white, they are easily seen, and as each egg-mass contains the embryos of caterpillars enough to eat up all the vines on a hill, the time employed in collecting it is not entirely wasted. During the winter, or in early spring, the fences surrounding the yards should be examined and the egg-masses picked off and destroyed. In this way yards can be kept free of this pest.

THE FALL WEB-WORM.

(*Spilosoma cunea* Drury)

In several yards I noticed the vines on a number of poles enveloped by the web of the common Fall web-worm, so often seen on fruit trees. There is no need to describe the insect, as it is so well known, and there is no need for hop-growers to suffer any loss from it, for the whole colony can be destroyed when first noticed by simply cutting off the arms and leaves which are spun up and trampling them under foot.

THE HICKORY TUSSOCK-MOTH.

(*Halesidota caryæ* Harr.)

At Waterville and vicinity I found a number of caterpillars, when fully grown about one inch or a little more in length. The head and under side of the body are black; the upper part, so far as can be perceived, is white, sprinkled with black dots, and with transverse lines between the rings. They are covered with short, spreading tufts of white hair, with a row of eight black tufts on the back, and two long, slender, black pencils on the fourth and tenth rings. The tufts along the back are so close together as to form an apparently unbroken ridge of short, dense, and somewhat bristly hair. The hair on the front part of the body is longer than the rest and overhangs the head. These caterpillars are full-grown about the 10th of September, spin a cocoon in some crevice, under stones or in heaps of rubbish, and transform into a brown chrysalis. In June following the moths appear. They expand from 1½ to 2 inches; the fore wings are long, pointed, of a pale ocher-yellow color, finely sprinkled with brown dots, and crossed by four irregular rows of large white and semi-transparent spots.

The caterpillars do not seem to feed very heartily, as even where they were most plenty the leaves were not noticeably eaten. They are nowhere very abundant, have not been known to do any serious injury, and are probably kept in check by the fact that before they are ready to spin up the vines are cut down, and then, when forced by want of food to make their cocoons in the piles of vines, they are destroyed when the vines are burnt.

THE HOP PLANT-LOUSE.

(*Aphis* [*Phorodon*] *humuli* Schrank.)

This insect is well known to all growers, and was especially injurious during the past season, the hops being rendered universally of an inferior grade, and many spots so greatly injured that they were not picked. For many years past the hops have been more or less injured by lice, but this year they were especially abundant, the universal testimony of all growers being to the effect that never before had they known of such injury caused by them. Nothing at all was done to combat them, the worst infested parts of the yards only being first picked, sometimes a little before fully ripened, and most of the energy and ingenuity being devoted to bleaching out of the hop all trace of the "mildew" and "rot" caused by the insects.

As in respect to these insects my notes are full, I will simply transcribe them.

June 21.—At Herkimer, in Mr. Pine's yards, examined carefully for aphids, but find no traces of them. Mr. Pine says his low-lying yards

suffer most; he had them last year and previous years, but never sees them as early as this.

June 23.—At Mr. Harter's yard find no lice; it is a hill yard, cleanly cultivated, flourishing, and remarkably free from insects of all kinds.

July 14, 15, 16.—Examined vines for aphids, none found any where.

July 17.—Went to Mohawk; saw Mr. Steele and examined his yard; no aphids; says his yard, being on a hillside, well drained, always a current of air through it, suffers very little from insects, and while he has each year *some* lice, he does not suffer any appreciable damage. Hot, dry weather favors hops and is bad for lice, the reverse is bad for hops, good for lice.

July 19.—Arrived at Waterville with Mr. Cutter, of the *Waterville Times*. I visited the Hannover farm; found the first aphids I had seen, very few indeed, small in size, wingless; a single one to a leaf only. Visited Mr. Risley's yard; no lice here. Visited Mr. Coggeshall's yard; lice more plentiful here than anywhere else so far, and yet not numerous; they had evidently been here for some days, because there were large specimens, and on the same leaf a varying number of small and very small specimens, as many as seven or eight on a leaf, evidently the progeny of the old one. Not many leaves are affected, however, mainly the lower, large leaves, and very dense vines are more affected than the others.

July 20.—Visited the Hop Extract works, and spent most of the day in the yards there; the low, wet yard has a fair sprinkling of medium sized and very small wingless lice. The hill yard is as yet clear. Mr. Lawrence says a few sultry days will suffice to cover the vines. He finds winged ones in immense numbers in late fall in his storerooms, but they disappear soon after, and he never saw them in winter.

July 21, a. m.—With Mr. Eastman, of the Hannover farm, visited hop yards toward Sangerfield and vicinity; lice everywhere now, but in small numbers; always more abundant on low ground. Saw "honey dew" for the first time. The current belief is that this is produced by the lice, but there certainly are not lice enough now to produce all this "honey dew." Mr. Eastman and Mr. Fees think the lice have nothing to do with it; say they have seen lice without honey dew, and honey dew in abundance where there were no lice.

p. m.—Went to Deansville and saw Mr. Jenks. Mr. Jenks is a microscopist and has paid some attention to lice; says he has seen winged lice, males, early in spring, *i. e.* about May 20; saw at that time also wingless forms, females. Finds both on the stem of the vines, not far from the roots and crawling upward; later finds them on the lower leaves and then they disappear for a month or more. They are beginning to reappear now. Has never found them on the roots in the winter and never looked for them; never saw them in grubbing time.

Cranberry insects now demanded my attention, and my notes cease until—

September 4.—Went to Mr. Risley's yard; find them picking; lice not over abundant; plenty everywhere, but not doing any serious injury to the hops; in a few places only the hops are beginning to show traces of mold; winged forms are scarce, but there are a few.

p. m.—With Mr. Cutter went to the Hannover farm; picking is going on, full blast; lice are not over abundant, less than they have been before the cold snap (the night of the 3d and 4th the temperature fell to the freezing point); winged forms in small numbers. Saw Mr. Sylvester Gridley and his yard; lice plenty; hops fair, but in some spots badly damaged by the mold caused by lice. This is the worst so far. Mr. Gridley says he has seen the lice when grubbing; he has cultivated hops for many years, has always had more or less trouble with lice, and knows them perfectly; he was superintending grubbing, and was called by some of the men to look at some hills they were at work upon; found that the young shoots were completely covered with lice; whether winged or not he cannot say; saw this on several hills; the lice were of full size. Mr. Gridley's men claim that they have found the lice on the poles when setting them in spring.

September 5.—Hop Extract yard. Lice here very abundant, especially in the low, "blighted" yard; in some places they form double layers; toward the tips and on joints they are especially plentiful, often forming balls half an inch in diameter; many leaves are sucked dry; they shrivel up, become brown, and die, and the inhabiting lice with them; many vines were entirely brown and dry; the hops were covered inside and out, and were all moldy and rotting. There are many winged forms and many with rudimentary wings—pupæ. I noticed none of these yesterday. The night has been cold; this day, warm.

September 6.—The night has been cold; at the Extract yards the lice are not more numerous, but pupæ and winged forms are largely on the increase. Went to Deansville and called at all yards on my way. Everywhere the lice are fearfully abundant, and the hops are molding fast. The entire crop this way is tainted and lessened in value. On a bag of hops picked yesterday and left out over night the lice cover the outside in a layer fully an inch thick. Where the vines have been piled up clumps of lice, 4 to 6 inches in diameter, aggregated into a globular mass of living matter, are seen. The number is incredible, and the thing must be seen to be believed or appreciated. Toward evening it became warmer and I noticed swarms of the aphids on the wing. Though I watched long and carefully I could not find that they mated.

September 7.—The night has been warm. To-day it is warm and showery. At the Extract yards lice are, if possible, more numerous than yesterday. A notable fact is that while yesterday there seemed to be no very small forms and a large number of pupæ, to-day there are many winged specimens, there are very few pupæ and a new batch of very

small specimens, evidently not many hours old, and on every leaf I observed the process of bringing forth living young. None of the winged insects were so engaged. These were more active and less patient of observation, nor did I observe that any pupæ or those forms with but rudimentary wings brought forth young.

p. m.—In Mr. Risley's yard lice less abundant than elsewhere. On the whole, Mr. Risley's yard and the yards in the immediate vicinity are much less bothered with the lice than any other yards I have seen. Nothing particular to note except the small number of winged specimens and the entire absence of pupæ.

September 8.—Rain; temperature warm; lice are not active, and reproduction does not seem to be going on, but I spent only a short time "between drops" in the yards.

September 9. Sunday; rain all day; temperature high; evening closed in warm and muggy.

September 10.—Went to Oriskany Falls, Sangerfield Center, and the Hannover farm during the day. Lice in all yards more abundant than ever. The vines are one mass of the beasts. Merely walking under them I became covered. On the stems, leaf-stalks, and especially at the joints, there were three, and even four, layers of the insects, while on the ground, globular masses, 4 to 6 inches in diameter, were everywhere seen where the vines had been pulled and hops picked; everything is covered with lice, and everywhere they show that same tendency to bunch themselves.

September 11.—At Cooperstown, called on Mr. J. F. Clark and saw his yard. Nothing noteworthy in his yard. In the yards between Richfield Spa and Cooperstown picking is about over, and here many have finished picking and all are nearly done. Mr. Clark says that this spring, when grubbing—about the middle of March—one of his men turned up with the grubbing hook a mass of living lice; the mass was globular and as big as a fist. The man, whom I questioned closely, says they were about 6 inches or more underground, near to, but not *on*, the roots; he called the attention of his fellow-workmen to them and they broke up the mass to make certain they were really lice, and he is positive that they were identical with the lice now in the yards. Cannot say whether any of them were winged. Mr. Clark, also, has noticed the lice on the vines when they were still very low.

September 12.—Spent part of day in Mr. Clark's yard and with him grubbing up hills where picking had been over for some time. Everywhere in the ground we found lice—rarely singly, but in small masses, from three to ten, or more. In recently-picked spots they were numerous and close to the surface; in older spots they were more scarce and much deeper down; one mass of eight was found at least 10 inches below ground. Afterward I examined the spaces upon which the vines from which the hops had been picked were piled; where the vines were

dry they were clear of living lice, but on the ground they were everywhere crawling, making their way into crevices.

Thus far the excerpts from my notes.

I remained for a few days longer, until picking was over and the lice had disappeared, most of them destroyed, no doubt, by the deprivation of food and the numerous enemies, in the way of predaceous larvæ and small beetles of the *Tachys* group, which were everywhere abundant in the yards; but a large number of fully-matured forms, apterous and winged, no doubt found winter quarters. As several persons claimed to have found the lice on the poles in spring, I examined many poles after they had been stacked. Where the yard had been but recently picked, lice were found on the outside, in the crevices, and under the bark. In yards that had been picked and the poles stacked two weeks or more, very few were found, and they far in the crevices and fissures; none under the bark or in the crevices of the bark. The probability is that but few winter in the poles.

A brief résumé of the results of my investigations is this: The lice are found in the ground as early as March (Clark); they are seen shortly after on the very young shoots scarcely above ground (Gridley); then on the young vines not more than three or four feet high, *apterous and winged* (Jenks). They disappear early in June, for notwithstanding close search I failed to find any, nor could I learn of any having been then seen. In July, about the middle or toward the end of the month, single apterous individuals appear on the lower leaves; these produce living young, which are also apterous, and in two or three days also produce like young; this continues until the weather becomes cold, and then winged individuals appear. When the hops are picked, the fully developed individuals enter the ground, crevices on poles, and probably other sheltered situations. In the early part of the season the results are all viviparous females; early in September winged individuals begin to appear.

As to the mode in which they do their damage: Numerous as they become, did they only attack the leaves or stems of the plant the abundant vitality of the plant would still ripen the hops, though they might not be quite so full; but not satisfied with the leaves they go into the hop, *i. e.*, into the burr, and there puncture the delicate leaves; the sap exudes, ferments, and a fungus attacks it—the hops mold, become specked, lose vitality, and finally decay. Not always do the lice enter the hop; sometimes they have been very abundant and yet hops have not suffered, because the insects confined their attacks to the leaves. Dry, hot weather will keep them out of the hop, and will somewhat retard their increase. Hot, moist weather, or rainy weather with cold spells, will in the one case so favor their increase that they will cover the whole vine; and in the other, while retarding their development, cause them to seek shelter in the hop itself.

Nor are all varieties of hops equally affected by the vermin. "Hum-

phreys" and "Canadas," both red and white, are not apt to mold, but the "English" and "Cluster" suffer greatly and mold readily. The reason for this is in the form of the hop. "Humphreys" and "Canadas", after burring out, remain open, *i. e.*, the burrs do not close or shut down as they do in the "Clusters." The result is, in the first case there is ventilation enough, the exudation from the punctures and from the lice does not ferment, and mold does not form; in the second there is no ventilation, and first fermentation and then decay set in rapidly. "Humphreys" suffer least of all, and as they are an early hop they can be picked before the final host which attacks the hop is hatched. "Canadas" come next; they are later, but not only is the hop less liable to mold, but the vine itself seems less to the taste of the aphids than are the "English" and "Clusters."

REMEDIES.

All sorts of remedies have been proposed and tried, with more or less success. Washes of whale-oil soap and syringing with decoctions of quassia have been tried by growers, with partial success. The numbers were decreased for a short time, but the loss was soon made up, and the labor was so great that operations were suspended, the more readily as the growers do not desire to risk tainting the flavor of the hop by washes.

The great error in all these cases was that the application was not made until after the insects were in full force, and the vines high up, almost out of reach; of course under these circumstances it was impossible to do more than temporarily reduce the numbers.

The attack should be begun in spring. When grubbing, the roots and young shoots should be examined, and any aphids that may be found destroyed. As the vines increase in size they should be carefully examined every few days, and when the lice appear these should be destroyed by hand, for the number will not be large and the method is certain. In my opinion it is now, if at all, that the winged female oviposits or lays her eggs—not more than one or two on a leaf, and probably close to the midrib. If this can be prevented it will save the crop, and that it should be prevented it is necessary to attack the insects when they first appear. Then, when the first of the late forms appear, about the middle of July, they will be found mainly on the lower leaves, wingless and in very small numbers; they spread very slowly at first, and afford the grower ample opportunity, should he desire to avail himself of it, for destroying them by means of washes or otherwise; as the season advances, they become numerous, spread all over the vine, and are then practically out of reach.

As good a wash as can probably be found is a solution of carbolic acid, either "Squibb's solution," containing 1 per cent. of the crude phenols, which can be diluted with seventy-five times its bulk of water and still

prove effective, or some of the many carbolic soaps recommended for that purpose.

Soluble phenyl (Little's) has been recently recommended as a valuable insecticide, and it is said that a teaspoonful of the liquid in four gallons of water will suffice to destroy aphids. If this be so (and it is worthy of a trial) it will make a very cheap wash, and should be freely used when first the insects make their appearance.

NATURAL ENEMIES.

The hop louse is not without its enemies in the insect world, and quite a number of species feed on it, and in ordinary years suffice to prevent its too rapid increase. Prominent among these are the "lady-birds" and their larvæ known as "niggers." Three species of the lady-birds are found in abundance on the vines. The most numerous is the two-spotted lady-bird (*Adalia bipunctata*), a small red species, with two black spots on the wing covers. Next comes the nine-spotted lady-bird (*Coccinella 9-notata*), a larger species, with nine black spots on its yellowish-red wing covers; and least numerous of all is the twice-stabbed lady-bird (*Chilocorus bivulnerus*), smaller than either, entirely black, except two blood-red spots on the wing covers. The larvæ of these species are all very much alike, of an elongate, flat form, tapering toward the tip, with six legs; of a grayish-black color, spotted and marked with red or yellow. They are very active and very rapacious, feeding almost continually, and each larva destroys many aphids before attaining maturity. When full-grown they attach themselves by the tail to a leaf, curl up into a round pellet, and in a few days transform into the perfect beetle, which also feeds on the Aphis, but is not so voraciously as the larva. There are several broods of the insect in the season, the last transforming into the perfect insect about the middle or toward the end of September. The beetles hibernate in crevices of fences, under bark of trees, or stones, or wherever else they can find shelter, and reappear in spring to continue the work where they left off the year before. Were it possible to preserve a sufficient number of these insects through the winter, so that a goodly number of them would be on hand in early spring, the lice would never become numerous enough to do injury; as it is, but few survive the winter, and before they become numerous the lice, propagating more rapidly, become so plenty that they are beyond control. But, seriously, there is no reason why these coccinellids cannot be wintered. They become very numerous in fall, and several hundreds of them could be collected without difficulty, put into a large box with plenty of loose rubbish, and put into some cool place not exposed to the fiercest cold nor yet so warm as to cause them to become active—a barn or cellar would answer. The box should be covered so as to prevent the entrance of spiders which would feed on them. In spring the box could be placed in the open air, and the insects would then scatter through the yards in search of suitable places to deposit eggs. I firmly believe that this could

be done without much trouble, and that this would prove the best possible remedy to prevent the spread of or damage by the aphids.

Another enemy is the larva of a Syrphus fly, which I find in small numbers on the vines. This larva is of a uniform yellowish-white color, about one-fourth of an inch in length, with a stout body tapering to the head. It is a slimy insect, with no perceptible legs or head, but a mere rounded opening for a mouth. It glues itself fast in a position where lice are abundant, and, stretching its head in every direction, seizes all lice within its reach, and when it has cleared all within its reach moves on to a new center of operations.

The lice are also attacked by a disease, apparently of a fungoid nature. I noticed several instances where all the lice on a leaf appeared unnaturally large or swollen, and of a brownish-yellow color. On being handled they crumbled into a very light brownish, granular dust. The disease does not appear to be widespread, and I cannot give any nearer details as to its nature or origin.

THE HOP-VINE LEAF-HOPPER.*

(*Typhlocyba* sp.)

An insect known as the "green fly" is pretty generally found in hop yards all through the summer, and sometimes very numerous. This insect has been said to "sting the heads" and to cause "slide down" or "foolish hills," while others claim it does no damage whatever. The insect is of a greenish to yellowish color, with a short, broad head, long, narrow body, and two pairs of wings, the first narrow, long, and yellowish-green, with a dark dot on each, the hind wing broad and transparent. The legs are yellow, the posterior pair very long and stout, the shanks set with spines, and as a whole fitted for leaping. The young or immature forms resemble the full-grown insects in all points, except that they want wings. They are very active, leaping off at the least disturbance, and when full-grown using their wings as well as their legs to good advantage. The adults hibernate in crevices, in barns, or wherever they can find shelter, and appear in spring as soon as vegetation appears. They mate and breed all through the season, and become very numerous occasionally. They seem to be somewhat local, as in some yards I could not find them at all, while in others close by they were abundant. As a rule, yards badly infested with aphids had none of these hoppers, while Mr. Risley's yard, which was by all odds most free from aphids, had these hoppers more numerous than they were elsewhere.

These insects do not damage the hops; they are found most usually on the lower leaves (*i. e.*, not more than 5 or 6 feet up the pole), and feed by puncturing one of the ribs and sucking the sap. The injury done by them consists in so weakening the veins that they are unable to

*This insect is an undescribed species of *Typhlocyba*, but the material received and submitted to Mr. P. R. Uhler is considered by him in too poor condition to permit of proper characterization.—*C. V. R.*

accomplish their work, and the leaf loses vitality. Where these insects have made a puncture on the rib, a woody scar remains, and where these scars are numerous those parts of the leaf farthest from the main ribs are thinner and more flaccid than in healthy leaves; and such leaves, and no others, are affected by the "honey dew." A few of the leaves turn brown, but the vine is not in the least injured and the quality or quantity of the crop is not in the least affected.

The same remedies used against the Aphis will prove useful against these insects.

In addition to the insects hereinbefore enumerated, there are a few beetles, belonging to the *Chrysomelidæ* or leaf-eating beetles, and principally the flea beetles. Most common of the latter is the red-headed flea beetle (*Systena frontalis*), a black beetle about a quarter of an inch in length, with a red head, and with very heavy hind legs; a good jumper and no mean flyer. Next comes the striped flea beetle (*Phyllotreta vittata*), a black beetle less than one-tenth of an inch in length, with two yellow stripes on the wing covers. Finally comes the punctured flea beetle (*Psylliodes punctulata*), a brownish species, less than one-sixteenth of an inch in length. None of these are very numerous, and they are not found in all yards nor all together in any one yard. They eat small holes in the leaves and do no great damage.

The twelve-spotted leaf beetle (*Diabrotica 12-punctata*), a yellow beetle about a quarter of an inch in length, with twelve spots on the wing covers, has the same habit, and appears in small numbers in all yards.

OBSERVATIONS ON THE ROCKY MOUNTAIN LOCUST DURING THE SUMMER OF 1883.

BY LAWRENCE BRUNER.*

WASHINGTON, D. C., *October* 30, 1883.

SIR: Herewith I submit to you a report of my trip through the Rocky Mountain region during the past summer, made for the purpose of studying insects injurious to agriculture, but more especially for the purpose of obtaining such data as would enable me to foretell the probable aspect of the locust question for the year 1884.

According to instructions, I left here on the 3d of May, and proceeded to my home at West Point, Nebr., where I procured an assistant and completed my preparations for the trip. From there we first proceeded to Albuquerque, N. Mex., via the Union Pacific and the Atchison, Topeka and Santa Fé Railroads, where we made a short stay, obtaining such data as we could relative to locusts and other insects injuring grain, vegetables, and fruits. Upon our arrival there we found the season very backward and all kinds of insects quite scarce; hence, after a few days' collecting, we proceeded northward to the Taos Valley, a rich farming district, where we spent almost two weeks gathering such data as we could concerning various insects. In these efforts we were much inconvenienced by the prevalence of small-pox in the various villages throughout the valley, and on account of the backwardness of the season, as well as the extreme ignorance of the natives in general upon questions relative to insect life. We did, however, succeed in obtaining some data in reference to the migratory locust (*Caloptenus spretus*) during the years of invasion. We also procured a small series of some of the insects found here in early spring.

Upon leaving Taos Valley we proceeded northward by wagon to Fort Garland, Colo., crossing on the way several small valleys in which farming is the chief occupation of the inhabitants. Here, too, we encountered the difficulties experienced while at Taos and neighboring villages, at times finding it difficult to obtain even the necessities of life. At Fort Garland we were detained several days on account of the sickness of my assistant. While here, the weather was quite cold and the post

* Mr. Bruner's instructions were, in brief, to make all necessary preparations at his home in West Point, Nebr., and thence to proceed directly to South Colorado and New Mexico, spending a week or more in the Taos Valley. Thence he was instructed to return north by way of Fort Steele, and work into the Big Horn country, eventually striking the Northern Pacific Railroad and proceeding to Fort Buford, and thence directly home.

The chief object of the trip was to ascertain all facts relating to *Caloptenus spretus* in the country indicated that would enable him to make a report as to the prospects for 1884, and also to collect facts upon insects injuriously affecting any cultivated crop in the settled portion of the region traversed.

was visited by a snow-storm. From this locality I forwarded to the Department a sample of plant that is said to kill stock, and is known in this section as the "loco" weed.* From Fort Garland we returned northward via Denver and Rio Grande Railway to Denver, and thence to Fort Collins, where we were detained until July 1 on account of the scarcity of funds. While there, we occupied the time in collecting and examining wheat fields for insects, as well as in studying the preparatory stages of different locusts. From Fort Collins we proceeded by wagon to the North Park, where we expected to obtain some data and material in special directions, but upon our arrival in the park we found we were too late to procure what we were after. We therefore, after learning that the streams were still too much swollen to reach the higher elevations, proceeded to Laramie City, Wyo. After a few days' detention at this point we left for Rock Creek Station, on the Union Pacific Railway, from which latter point we proceeded by stage to Junction City, Mont., the route by which we traveled taking us across the well-grassed plains between Forts Fetterman and McKinney and along the eastern flanks of the Big Horn Mountains, a section admirably adapted to be a breeding ground for *C. spretus*. On this trip we laid over a few days at Fort McKinney and part of a day at Custer's battle-field, to collect.

From Junction City, with your permission, we deviated from the original plan and proceeded westward instead of following down the valley of the Yellowstone to its junction with the Missouri and thence across the plains lying to the northward between this river and the Souris. We first went to Bozeman, where we procured horses, after which we rode across the country via the valleys of the Yellowstone, Upper Madison, and Snake Rivers into that of the Salmon River. On this trip we also collected at various points along the route, besides making numerous inquiries relative to the migratory locusts. Upon our arrival at Salmon City, Idaho, we found that our time which had been allotted for field work had almost expired. After a few days had been spent upon the object of our trip, we returned to the railroad, where we took the train for Ogden. Arriving at Ogden, we found that we still had some time at our disposal; we therefore devoted it to collecting and in visiting the orchards of several of the principal horticulturists, both in the vicinity of Ogden and Salt Lake City. From Ogden we returned to Washington *via* West Point.

I am pleased to be able to report that the leading feature of our notes for the summer's work is the comparative freedom from all insect plagues throughout the entire area traversed by us.

The report you will observe is chiefly in the form of notes as they were taken down from time to time while in the field.

I am, respectfully, yours,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
United States Entomologist.

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* *Oxytropis lambertii.*

MIGRATORY LOCUSTS.

TAOS VALLEY, *June* 2, 1883.

The first locusts of which I could learn came into the Taos Valley from the east during the latter part of May, 1876. They were exceedingly numerous, and during the summer, all through which they remained, they destroyed almost the entire grain crop, leaving a little in only two or three small sections to the south and west of the town of Taos.

In the fall (September) of the year they deposited numerous eggs, which hatched the following spring in great numbers, and much damage resulted during spring and summer (1877). After attaining wings, a few left to the westward, but the majority remained and deposited their eggs, which produced a third brood in the spring of 1878.

In 1877 the crop averaged nearly one-half, and in 1878 a trifle over a half of the usual yield, but this last year many farmers had become discouraged and refused to plant; hence the crop planted was below the average for the valley. During the locust visitation several modes of warfare were tried by a few of the most enterprising citizens, but without any great or decided results. It is related that when the locusts first appeared the storekeepers then in the valley offered the inhabitants as a bounty a pound of coffee for each pound of locusts captured and killed. At first this was not hard on them, but shortly, as the country folk learned how to capture the locusts, the offer was withdrawn, as the coffee went too rapidly and without any apparent diminution in the number of locusts. Methods for the destruction of and protection from the young were various, and in most instances quite similar to those adopted in other portions of the country. Coal oil or kerosene was used in mixtures of various strengths and sprinkled on the crops, which for two or three days after the application was quite effectual in keeping off the young, but gradually, as the scent of the oil disappeared, the wheat also began to disappear before the little 'hoppers. Several tried oil on the surface of the water in the irrigating ditches with some little effect for the time being, but all to no purpose in the end. Another method, and by far the most unique used, was the spreading of wagon sheets on the ground, after which the little hoppers were driven upon them, and then the sides gathered up and several large round stones dropped in and rolled about by keeping the sheet agitated until all the little fellows were killed. I was assured that a very large number of the young were destroyed in this manner.

During the summer of 1878 those locusts that matured left to the westward, and it is claimed that since then none of this species have been seen in the valley.

There is a valley 20 miles south of here in which there were a few in 1879 and also in some isolated spots in 1880, but during neither of these years did they do very great or general injury to the crops over the valley. While in these valleys, in this portion of New Mexico, it is claimed that

their movements were in unison, but not extensive, their flights being very short.

The average elevation of Taos Valley is about 7,000 feet. Not a single specimen, young or old, of this insect was observed from the time of leaving Poudre Cañon to the time of reaching Laramie City on the 10th of July, nor have any been seen or heard of since. While in North Park, Mr. Capern stated that but few had been observed by him since 1879 and 1880, when quite a number had hatched in portions of the park; and it was during these years that they were frequently seen in the air, floating with the wind. From Laramie and Rock Creek, north, we were ever on the lookout for signs of this insect, but failed to see any before reaching Fort McKinney. At this place we succeeded in capturing two fledged specimens and saw but one or two others. We did not ascertain much about their past ravages in this part of the country more than that, in 1877, they had been seen in the air in great numbers; also in 1876, and once or twice previous to this, when they flew in great numbers, and occasionally were noticed piled up in heaps upon the snow on the mountains where they fell as they became numbed while trying to cross the range. Again at Custer's battle-field we saw two or three more among the numerous other species of locusts that abounded among the rich grasses of the bottom lands and coulees, as well as lower hillsides. At Junction, on the Yellowstone River, none of this insect were noticed, though several allied forms were abundant both on the river bottoms and among the sage-brush and bunch-grasses back among the hills and on the bench-lands. At Livingston, where the railroad leaves the Yellowstone Valley, we noticed a great number of locusts, which, when I first saw them from the car windows, jumping about in the grass, I took for this species. Upon going out, the mistake was quickly observed. While there did not appear to be any *C. spretus* among the hosts of locusts, there were quite a large number of *Camnula atrox*, or *pellucida*. I also observed several of this species here in the vicinity of Bozeman (August 3). I have not, however, been able to learn of any damage having been committed by them in this valley the present season. Since leaving Bozeman, and while crossing the country along the Yellowstone River, we did not observe a single specimen of *C. spretus*, either old or young, in the air or on the ground. During past years, however, they were reared in great numbers throughout the National Park and Upper Snake River valleys when, at times, they were numerous enough to "almost obscure the sun"; at least I was so informed by a Mr. Livermore, who has a ranche at Henry's Lake.

As to dates and particulars of flights, &c., he was not certain; therefore I can give none of these. As we proceed down the valley of Henry's Fork toward the Snake River there is a great tract of country crossed that at times has been the originating center for the great swarms that came into Cache Valley and other portions of northern

Utah and southern Idaho; it is also quite impossible for me to give any of the particulars as to dates, &c. Thus far (August 23) we have not met with a single *C. spretus* in Idaho, nor have we heard of their presence in any portion of the Territory. But as there is no accurate account extant of the locust history for the region of Salmon River Valley and adjacent country, it may be well to give it in brief here. The first reliable account that I could obtain in reference to locust swarms dates back to the summer of 1869, when they came in from the Snake River by way of Birch Creek and Wood River, and followed northward down both the Lemhi and the main branch of the Salmon to about Salmon City. These deposited eggs, thereby giving young locusts for 1870. Again, in 1871, locusts appeared in the vicinity of Lemhi Agency and Salmon City. From this time on till the summer of 1875 I was unable to learn of their appearance or presence in this portion of the Territory, but during this year (1875) they again appeared in great numbers, coming as before from the southeast and south, following down the valleys of the two rivers heretofore named. This summer, as well as during the three following, they deposited great numbers of eggs and proved exceedingly injurious to the few crops of grain and vegetables that were planted in the country (valleys). Since 1879, however, they have entirely disappeared from these regions. The time of their appearing in the valley of the Salmon, I am told, varies from the middle of June to the first of August, after which latter date, if none have already come, the farmers consider themselves entirely safe as far as locust swarms are concerned. From what I could learn, there are no exceptions to the northward movement of swarms of *C. spretus* in this particular portion of Idaho, and judging from the surface configuration of the lower Salmon River country, I would imagine that all swarms leaving must cross over the range to the headwaters of the Bitterroot and Big-Hole Rivers, which streams they follow down, and thereby divide and reach different portions of the Territory of Montana. As far as my inquiries went, no data were obtained of methods having been adopted for their destruction in the various stages of their growth, which differed in any way from those used in other portions of the West, and already described in former reports. The parasites, too, do not appear to have varied from those in other sections of the locust area.

CAMNULA ATROX.

In connection with the migratory locust this insect deserves separate notice, as it has been observed at various points along our route from Fort McKinney to Beaver Cañon, Idaho. At some of the points where seen it was quite numerous and threatened mischief, while at others there were but a few isolated specimens observed.

We observed them at the following localities: Bozeman, Trail Creek, Gibbon River, Lower Fire-Hole Basin, Henry's Lake, and on Camas Creek. Their habits, of course, are already known, and need no further

mention in this connection. However numerous this insect has thus far become in the mountain districts of Idaho, Montana, and Wyoming, I have failed to learn as yet of any depredations having been caused by it in these Territories, though I am unable to predict what they will do in the future, but my opinion is that they need not be feared. This, of course, is only an opinion based upon no facts. From observations made during the period of three years in this portion of the country they appear to be on the increase, and at other points not seen by me heretofore were quite common this summer. Whether they have migrated into these new sections recently or whether they already occurred there during previous seasons and were overlooked I am unable to say. None have been noticed in the act of migration thus far this season, though at Livingston, on the 2d of August, they were seen by far the most numerous, and were very restless and kept up a continual hopping and flitting about as if desirous of doing something besides being quiet and inactive. One thing we can be pretty sure of in connection with this insect, viz., that it will never leave the mountains and higher altitudes for the agricultural districts of Dakota and Nebraska, which lie to the east and southeast of here, because they are not capable of such long continued flights as are other species.

C. spretus.

Again, in the valleys of the Great Salt Lake Basin a few specimens of this insect were observed, which were, as a rule, confined to meadows and low, wet localities, away from fields of grain and garden patches, and I do not think they will ever become numerous enough here to do great damage to the products of the farm.

"*NATIVE LOCUSTS.*"

There were but three or, at the most, four species of locusts which had attained wings to be found near Albuquerque, N. Mex., viz., two *Œdipodæ* and one *Psoloessa*. They all frequent comparatively dry localities where the grass is beginning to show a little green. They are quite active, are easily disturbed, and fly rather far at each start. Among the young not yet matured but two species were discerned, viz., one *Œdipoda* and a *Caloptenus* or *Pezotettix*. These latter were only met with in fields of alfalfa, along irrigating ditches, and then only occasionally.

At Santa Fé we saw several specimens of the *Psoloessa*, and also two or three specimens of some species of *Arphia*. In passing along the road from Santa Fé to Espanola, as we approached the sandy flat, and also as we crossed it to the south of Santa Cruz, quite a number of a large, yellow-winged *Œdipoda* (*Hippiscus haldermannii*), were seen. It was the same as the largest one taken at Albuquerque.

At Espanola we observed a few of the same three species mentioned above as having been taken at Albuquerque. Again, at Embudo, we

collected a few of these locusts, and, in addition, several specimens of the *Arphia* mentioned as having been seen at Santa Fé. It was found to be partial to the high, rocky mesas, about 1,000 feet above the Rio Grande. Here we also took several pupæ of some Tettigidean, which frequents low, wet places near the river. Going into the Taos Valley we found about the same species heretofore mentioned, with the addition of the larvæ of several others, but in no case could any of these be referred to *Caloptenus spretus*, although there appear to be some representatives of the genus *Caloptenus* found there.

Two species of *Chimarocephala* were met with in the rank vegetation (willows and cottonwoods) at Red River, and some larvæ and pupæ of one or two species of *Pezotettix* were taken. These were found among the sedges along the river.

At Fort Garland, *Arphia* and *Chimarocephala* are represented along the valley of Ute Creek in fair numbers, and as one walks along among the trees numerous males of these species are to be seen in the air.

After leaving Fort Garland, I did not notice any locusts until we reached a point below Laveta, where the train stopped for something, and I heard the rattling noise made by some species of *Gomphocerus*, and after searching a while succeeded in capturing a male specimen. A few immature specimens of several other species were also observed, but not captured. Between there and here (Fort Collins) no stop was made, and consequently no specimens taken or no locusts of any kind noticed. Here, in the mouth of Poudre Cañon, 12 miles to the northwest of Fort Collins, since the numerous heavy rains, there is a great variety of locusts, mostly young, of which we have taken large series. These are, however, all "natives." Almost all of them are such species as are partial to certain plants, or else to particular kinds of surface configuration. These peculiarities can, however, be better set forth in a work entirely devoted to the history of North American locusts.

There do not appear to be any species of migratory locusts here at present; none have been noticed in the air or on the ground. Specimens of *Caloptenus minor*, with both blue and red tibiæ, are quite common here; in fact this is the only species of fledged *Calopteni* that I have thus far observed in this portion of Colorado this spring, though the young of several species are occasionally met with. I have also taken a few specimens of what to me now, without comparison with description, appear to be the *Pezotettix dodgei* of Thomas. *P.* (*Dactylotum*) *pictus* is just now commencing to hatch, while some of the *Stenobothri* and *Œdipodæ* have reached the pupa state.

At various points along the route we observed a few species of "native locusts" in various stages of development, though none were taken except at a point on Laramie Plains, until we came to the Laramie River. These were a species of *Gomphocerus* that was found about 10 miles from Tie Siding, and its peculiarity consisted in the close re-

semblance of the noise made by the males to the rattling of a rattlesnake.

At Laramie River, where some little time was occupied in collecting, we obtained, in addition to such forms as were taken in the vicinity of Fort Collins, a few specimens of a greenish-white *Psoloessa* that was only observed to feed upon the "sweet" or mountain sage. In the North Park no additional species were taken or noticed, while all forms appeared to be rather scarce and wild. The genus *Arphia*, however, seemed to be the best represented in forms. A few specimens of *Caloptenus minor* were noticed among the dense vegetation along boggy and damp places. After coming out of the park and entering the Laramie Plains on the west side of Laramie River, a few locusts, though nothing new, were taken. On the 18th of July a few specimens of a light greenish *Gomphocerus* were taken at Aurora, where they were found to be partial to the common sage-brush (*Artemisia tridentata*). *Stenobothrus occipitalis*, a species with light gray antennæ, was also taken.

Between Rock Creek and Fort McKinney but very few locusts of any kind were noticed, and none were taken. At Fort McKinney we captured a large number of various species of locusts, among which were several of interest, on account of their rarity in collections as well as in their peculiar habits. During the summer we observed that quite a number of locusts are partial to certain food-plants; and, as a rule, in all such cases they imitate in color, to a certain degree, very closely the plant or plants upon which they feed.

Pezotettix albus, Dodge, feeds upon a white Artemisia. *Pezotettix borckii*, which is only to be met with in the mountains of Montana, Idaho, and Wyoming, appears to abound only where two or three particular plants are met with, one of which is a species of geranium. Again, *Caloptenus turnbullii*, which is found in the vicinity of Custer's battlefield, only feeds upon two species of plants, as nearly as I could ascertain by observation, viz., the "pig-weed" and a small greenish-white plant of a similar nature. Those found on the pig-weed are somewhat glaucous yellow, while those feeding on the other plant are more of a whitish color, mingled with greenish blue instead of greenish yellow. In like manner two species of *Caloptenus*, perhaps the *Melanoplus devastator* and the *M. cinereus* of Scudder, feed upon the sage brush (*Artemisia borealis ?*, and *A. tridentata*). The latter is grayish in color, and when at rest, both in the preparatory and the imago stages, is difficult to detect, so nearly does its color coincide with that of the plant upon which it is resting. Other locusts are not partial to certain food-plants, but appear to be so to certain soils and surroundings. For example, all those species of *Œdipodinæ* which would naturally fall under Mr. Scudder's genus *Circotettix*, love barren and rocky slopes and hillsides, the different species living at different altitudes and on differently colored soils. The species all love bright and warm sunshine, and during such times are very active and remarkably noisy, being almost incessantly in the air, where

they keep their wings clattering and rattling to such an extent that one would suppose they were rattling into pieces. We did some collecting at Custer's battle-field, where we took a large variety of species, as well as in most cases a large series of specimens. Here we also observed to a great extent the partiality which certain species exhibited in the selection of special food-plants. Again, at Junction City, Mont., we made some collections, adding a few to the list of species taken. Here, for the first time, we took several specimens of a species of *Œdipodinæ* belonging in the genus *Mestobregma*, and which almost exactly imitates in color a species of *Psoloessa* which we took on the Laramie River, south of Laramie City. While these two insects so closely resemble each other in color they are quite distinct, and as Scudder has subdivided the genus *Œdipoda* they fall into distinct genera. The two species in question, however, are both partial to the same food-plant, viz., the white or sweet sage, and thus far I have found neither away from where this plant abounds.

We again collected at a point on the Yellowstone River about midway from Trail Creek to the National Park, at the Mammoth Hot Springs, and at Henry's Lake. It was at the former of these localities that we found the *Mestobregma* most abundant.

While passing along the road near Gardiner, a new town, which is to be the terminus of the Park branch of the Northern Pacific Railway, we captured a few specimens of the same species of light-blue-winged *Trimerotropis* that I took last year at Fort Benton, thereby extending its range at least to the southern border of Montana. It appeared to be quite rare even in its special haunts, viz., a light, almost bare, whitish, alkaline soil destitute of rocks. It was also taken in the Lemhi Valley of Idaho. At this same locality several other species of closely allied locusts were taken. After crossing the main Rocky range to the west side a change in the comparative abundance of some species and in the total absence or replacement of other species was observed.

While on the eastern slope we found *Circotettix carlingianus* quite abundant and *C. undulatus* rather rare, on the western side of the divide we found just the reverse.

The large, red-winged *Hippiscus* which on the east side is everywhere so abundant, and in fact all the red-winged forms, have thus far been exceedingly rare, only four specimens having been seen during the five days that have passed since crossing the summit. A species which, on the eastern side, was met with but occasionally has become quite plentiful. It is perhaps what Mr. Scudder has called *Psinidia wallula*.

Thus far we have found locusts to be most numerous in species at an elevation varying from 2,500 to 6,000 feet above sea-level, and on the bench-lands in preference to either bottom or mountain lands. While most of the *Caloptenus* and *Pezotettix* were partial to moist localities where vegetation was rankest, the *Œdipodinæ* and *Stenobothrini*, &c.,

were most common on partially bare and dryer grounds where the vegetation is less rank. Color of wings and tibiæ does not necessarily indicate specific differences.

DESCRIPTION OF SURFACE.

The Taos Valley extends from the Arroyo Hondo, or deep ravine, of the Rio Hondo, or deep river, on the north, and from the cañon of the Rio Grande on the west to the foot of the Taos range of mountains on the east. It slopes to the southwest from the mouth of the Rio Hondo cañon, which has an elevation of 7,800 feet, to the edge of the Rio Grande cañon, which is about 6,400. The greater portion of the country is of a drift deposit, and consequently is mixed with bowlders and fragments of rock from the bordering mountains. It also is very rich when irrigated, which can be done over almost every portion by some one of the various beautiful mountain torrents that traverse the valley towards the Rio Grande. At present all or nearly all the farming is confined to the upper portion of the valley bordering the mountains, but I am satisfied that the lower portions, which are at present occupied by sage-brush, will be equally productive with the aid of water.

The surrounding mountains are rich in minerals, and only await the approach of railroad communication to be developed. With this, farming will also necessarily increase and the region become one of the richest in this section of New Mexico. Stock-raising is confined chiefly to goats, a few sheep, burros, hogs (which are picketed out), and a few cows. An abundance of chickens, too, is also raised in some parts of the valley. (Eggs and wood always one price, the former 25 cents for 16, and the latter same per load.) In passing north from Taos we enter the valley of the Rio Hondo. This latter is a stream of almost double the size of any of those passing through the Taos Valley, but differs from them by running in the center of a deep, narrow, cañon-like valley; most of this, however, is farmed, as is the high mesa on the south side of the valley, which latter slopes toward the Taos Valley. The upper end of this mesa, at the base of the mountains, is about 8,000 feet above sea-level, and descends toward the Rio Grande at the rate of about 100 feet to the mile. After leaving the Rio Hondo a low spur of the mountains, or high, irregular mesa, partly of volcanic rocks and covered with piñon pines and cedars, is crossed. This, at the highest point, reaches an elevation of 8,215 feet at a distance of between 2 and 3 miles from the mountains, which at the general slope of the country would be about 8,500 at the base of them. From this point the descent toward the Red River is quite rapid, this latter being about 7,400 feet where it leaves the mountains, and about 100 less where it enters the cañon at the foot of the valley, and preparatory to entering the Rio Grande. This valley, like that of the Rio Hondo, is comparatively narrow, and pretty well occupied by farms.

On the north edge of this valley begins what is known as San Luis

Valley, a plateau-like area of land about 140 miles in length and varying from 20 to 30 miles in width, or perhaps a little more, if we include that lying to the west of the Rio Grande. The general elevation of this valley along its eastern border is about 8,000 feet, sloping gradually toward the Rio Grande on the west. It is bounded all along the east by high, snow-covered mountains, and on the west by a series of volcanic cones and basaltic ridges. Some of these also, at isolated points, are to be seen protruding from the valley itself. All the way from Albuquerque, N. Mex., to this point (Fort Garland) the Rio Grande appears to be the dividing line between the basaltic and the other rocks, the basalt only appearing at isolated points near the river on the east side. The general surface of this entire valley is somewhat sandy, and the soil is interspersed with bowlders and pebbles from the mountains. It is covered with sage-brush, interspersed with short grasses, chiefly *Bouteloua*. At various points small streams cross it, and it is along these that all the efforts at farming have been made.

North of Alamosa and west of the Sierra Sangre de Christo range the valley appears to be richer in natural grasses, and is dotted here and there by small, shallow lakes. Immediately to the north of Fort Garland are situated Sierra Blanca and Mount Baldy, two of the highest peaks in Colorado, and at their base runs Ute Creek, the valley of which contains some fine grazing lands and a few good ranches, where at times the locusts have bred in great numbers.

After leaving Fort Garland we followed up the valley of Trinchara Creek to Veta Pass, where we crossed over the range into the valley of the Apaches and Santa Clara—a magnificent farming and grazing section.

At La Veta the elevation is between 6,000 and 7,000 feet, but descends quite rapidly towards the Arkansas, where the country expands into a wide, somewhat rolling country, dotted here and there with rocky ridges and coal fields. This country lies north of the Spanish Peaks and south and east of the Rainy range of mountains. This entire area, with the exception of a few small patches, is quite suitable for the propagation of locust swarms, and at times undoubtedly has been the seat of great swarms, although I failed to obtain any data concerning this insect for this particular locality. At the time of passing through here (June 10) the vegetation was quite green and the country looked well, although around Ojo, in the head of the valley, the oaks had not yet leafed out. On the summit in Veta Pass, where the elevation is about 10,400 feet, there was about 6 inches of snow.

Of course these extensive plains, that are so admirably fitted for the development of large locust swarms, sometimes have their drawbacks in the shape of seasons of great drought, as well as cold, wet, and backward springs following open winters, and in such cases the locusts suffer decrease here as elsewhere. From here we passed through such country as has already been often described—that lying between Pueblo and Den-

ver and between Denver and Fort Collins. At this latter place there is, as at Golden, a series of low mountains lying in front of the main range and separating the open country from a series of fertile valleys and park-like areas that lie back among the foot-hills and low mountains. These valleys and park-like openings among the foot-hills and low mountains are richly clothed with nutritious grasses, and are mostly well watered, thereby affording good footing for the breeding of locusts during years of their presence in this section of the country, and being every year the home of scores of species of "natives." It is in such localities as these that the greatest variety of locusts of all sorts is to be found in Colorado.

What is known as the Livermore country, on the North Fork of the Cache la Poudre, is a widening out of the valleys and park-like tracts into quite a large area of good farming land and a better grazing region. This Livermore country continues to stretch out to the west and northwest until it is lost among the park-like openings on the summit of the Laramie Range, south of Sherman; and from here is joined to the Laramie Plains on the west slope by valleys sloping that way. The Laramie Plains require no description here, while the numerous small parks lying to the south of the Laramie River, and between it and North Park, can be described as being merely openings in the timber, varying from 7,500 to 8,500 feet above the sea, and they at times form splendid retreats to the locusts and excellent grazing areas at all times to cattle and the large herds of game that frequent these parts of Colorado. During the summer and fall of 1880, a greater portion of this country, lying between the Laramie River and the North Park, was overrun by fires, during the progress of which, without any doubt, great numbers of both migratory and native locusts must have perished from heat and smoke. North Park is a vast grassy tract surrounded on all sides by high ranges of mountains, and shows plainly by its leading features that it was at one time the bed of a vast lake. Its lower end is about 7,600 feet in altitude, while all the other portions are higher. It is well watered and grassed, thus rendering it one of the most reliable grazing regions in northern Colorado. While its altitude is too great for safe adventure in general farming, it will nevertheless produce excellent crops of vegetables and small grain. Its entire surface could be burned over with some result in locust years.

PRELIMINARY REPORT OF OBSERVATIONS UPON INSECTS INJURIOUS TO COTTON, ORANGE, AND SUGAR CANE IN BRAZIL.*

By John C. Branner.

Sir: On the 20th of November, 1882, I was, upon your recommendation, and under your direction, commissioned by the Commissioner of Agriculture to visit Brazil for the purpose of investigating the subject of insects injurious to cotton, cane, and oranges; and to collect such other information as would be useful to you in your capacity of United States Entomologist.

On the 30th of the same month I left Washington, D. C., accompanied by one assistant, Mr. Albert Koebele, and left Newport News, Va., on the 2d of December, on board the British steamer Borghese. Landing at St. Thomas, in the West Indies, on the 9th of December, we took advantage of the few hours' delay of the steamer in that port to examine what cotton and other industrial plants we could find for injurious insects. We collected some scale insects on the "sapadilla" tree and sent them to the Department. We found no injurious insects on the few cotton plants examined.

We left St. Thomas on the same day and reached Para on the 18th of December. Here we improved the opportunity to examine orange trees for scale insects, and in the few hours we were able to spend on shore we made a small collection of insects from these trees. Fortunately we were able to visit the Natural History Museum of this province, which we did in hope of finding something interesting in the way of insects injurious to vegetation, especially of those attacking cotton, cane, and orange plants. No such insects, however, were found in the collection.

I made inquiries of the officers of the Brazilian navy station at the marine arsenal at Para concerning the winds prevailing along the northern coast of Brazil, and along the Amazon Valley. I made similar inquiries of the commanders of the steamers plying on the Amazon and

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* The principal objects of Mr. Branner's trip to Brazil, as detailed in his letter of instructions, were as follows:

1. The gathering of historical information upon the culture of cotton in Brazil, including the determination of the species of insects known to affect the crop there, and the collecting of facts relating to their habits.

2. To ascertain whether or not *Aletia xylina* is found in the vicinity of Bahia, and to collect specimens n all stages of this and allied insects.

3. To obtain as complete memoranda as possible of the prevailing course of winds at different seasons of the year.

4. To obtain specimens and information relative to the insect enemies of the orange and the cultivation of the crop.

5. To obtain specimens in all stages of the destructive locusts of Brazil, together with publications on the subject.

its tributaries, and especially of those who have run on the river for a number of years.

We left Para December 19, and on the 22d arrived at Maranhão. At this place the delay of the steamer was too short to allow of any investigations, however short, in the field. I had time though, to call upon his Excellency, the President of the Province of Maranhão, and to solicit his support in carrying on the investigations intrusted to me. He cheerfully promised to aid me in every way in his power, and furnished me with the names of such planters in the interior as would be able to answer any inquiries in regard to the diseases common to cotton and cane, and the methods of cultivation employed in this country. I am indebted also to Snr. Themistocles Aranha, the editor of the *Paiz*, the leading newspaper of the Province of Maranhão, for valuable historical information upon the subject of cotton culture in this part of Brazil.

On the 27th of December we landed at Pernambuco. My original instructions had been to proceed to Bahia to carry on my investigations, but sufficient liberty of action was allowed me to enable me to stop at some other point, should I find it better adapted to the purposes of my work.

Taking into consideration the importance of the province of Pernambuco as a cotton-growing district, as compared with the province of Bahia, the nearness of the cotton district to the coast, and its consequent accessibility, its geographical position in relation to the southern United States, and its proximity to the Bahia district, I concluded that it would be best for us to go into the interior from this place.

Before leaving Washington, we had, at your request, been furnished letters from his Excellency the Brazilian Minister at Washington, Snr. Lopes Netto, to various officials in Brazil. One of these letters was directed to the President of the Province of Pernambuco. On the day following our landing, I called upon his Excellency the President. He gave me a set of the reports of the Presidents for several years previous, from which I could collect information concerning the production of cotton and cane, and directed that letters should be given us to the local authorities in the places we might visit in the cotton-growing district. I called also upon Dr. Portella, for many years the president of the Pernambuco Society of Agriculture, to obtain information in regard to the localities most favorable for our work, and to learn also what had been done by the Society or by the Government in the way of investigating insects and diseases common to cane and to cotton in this province. He gave me some publications made by the Society, and presented me to other gentlemen who gave me valuable information in regard to insect pests, cotton culture, &c.

The cotton region, through this part of Brazil, lies just inland from the cane-growing lands, which form a belt along the coast from 35 to 50 miles wide. Toward the south of the province Garanhuns is the center of the cotton-producing area. Further inland the production is smaller,

owing to the increased cost of transportation, while along the coast cane is supposed to be more profitable and better adapted to the climate and soil. Distance inland, however, is not an insurmountable obstacle in the way of cotton culture here, for some of the places most noted for the amount and quality of cotton sent into the market are situated on the northern confines of the province, or even in the province of Parahyba, or in Ceará. It is no uncommon thing for cotton to be carried 400 miles on horseback. In the northern part of the province some of the principal cotton-yielding regions are about Bréjo, and in the province of Parahyba about Campina Grande and Independencia, while to the westward Riancó, in Parahyba, is a good cotton-growing district, as well as Pesqueira, Alagôa de Baixo, and Ingazeira in Pernambuco.

Although I conversed with many intelligent persons in the city of Pernambuco, several of them members of the Agricultural Society, upon the subject, I was unable to find out certainly whether such a thing was known as a caterpillar that devoured the leaves of the cotton plant. Dr. Portella informed me that many years ago—perhaps forty—some kind of a plague attacked the cotton so seriously that its cultivation was very largely abandoned by the planters. He knew nothing, however, of the nature of this plague. The only evidence I could find of the existence of such caterpillars in this part of the country was a verse of a popular song, formerly sung by the poorer classes hereabout. My attention was called to it by Snr. José de Vasconcellos, the editor of the *Jornal do Recife*. Aside from this, the only insect I could learn of as being injurious to cotton in any way was the locust, which, as I was told, sometimes ate the leaves.

After consulting with those most capable of advising me in such a matter, I decided that Bonito, in the province of Pernambuco, would be the best place for our work. The President of the Province and Dr. Portella furnished us with all necessary letters of introduction to the local authorities, and to such persons as would be able to aid us in the vicinity of Bonito, and on the 4th day of January, 1883, we left Pernambuco for that place. We took the São Francisco railway as far as Palmares, and there hired horses to carry us and our baggage to Bonito, about a day's ride to the north.

Remaining over night at Palmares, I met and conversed with some of the engineers in charge of the extension of the São Francisco railway.

In making inquiries in regard to the prevailing winds, I learned that a series of meteorological observations had been made by the engineer corps at this place, extending over a period of six years. I availed myself of the opportunity to copy the record, and consider myself fortunate in having this, the only carefully made series of observations that I am aware have been made so far from the coast in this part of Brazil. They cover the six years from 1877 to 1882, inclusive.

On the day following our arrival at Palmares we took horses for Bonito, and arrived at our destination in the evening of the same day.

The village of Bonito is a small one, on the southeastern border of the cotton-growing district. There being no hotel in the place, and it being impossible to arrange any other way to live and carry on our work, it was necessary to hire a house for these purposes. With considerable difficulty one was obtained, and preparation made for a short stay in the place.

Arriving at Bonito on the 6th of January, it was my expectation that we would be able to leave for the provinces further south, in which much cotton is grown, within a couple of weeks at the most. It was found later, however, that in order to carry out our investigations satisfactorily it would be necessary to remain at Bonito much longer than I originally proposed. The fact that we had arrived so early in the season, as far as insects were concerned, also made it necessary to remain here longer than would have been necessary had we come later, say in April or May, when insects are more active.

Once in the cotton-producing country, there was no difficulty in learning of the existence of caterpillars that destroy the plants. On the day following our arrival we visited some fields of cotton near Bonito, but, though we found various interesting insects injuring the plants, we were not able to find any indication of the existence of caterpillars. The people assured me that it was too early in the season, and that the weather was not of the kind favorable to these insects. The next day, however, Mr. Koebele found both larvæ and eggs, and, although they never appeared in large numbers during our stay at Bonito, from that time forth we found a few every day. In order to obtain as good a collection as possible of these insects in every stage of development, and of their parasites, we arranged to breed all we could find until our collections and observations were complete. At the same time especial efforts were made to find and raise caterpillars that feed upon other species of malvaceous plants. We had about a hundred breeding cases in our house for the different kinds of insects, parasites, &c.

We made observations on and collections of insects injurious to other industrial plants, such as oranges, coffee, corn, beans, tobacco, &c., and also of useful insects, such as bees.

Sugar cane is not grown at Bonito in sufficient quantity to allow of our doing much in regard to the sugar-cane disease, or insects affecting it. At the city of Pernambuco I learned that the Imperial Government had appointed a committee to investigate the causes and report upon remedies for the cane disease that has been doing great damage in this country for several years, but I was unable to find that anything had been made public in regard to what the committee had accomplished. The Pernambuco Agricultural Society had sent specimens of diseased cane to Germany for examination, and a short report from the gentleman to whom they were sent was given me. This report says that a

species of fungus was found in the specimen sent for examination, but that it is impossible to say whether the disease is caused by the fungus.

We made observations on and inquiries in regard to the direction of winds, the ravages of locusts, and insects injurious and beneficial to agriculture. Mr. Koebele captured a large number of moths at night upon the flowers of a species of *Cleome* that grew abundantly about our house. Among the noctuids were a very few cotton moths. The collection we made of these insects was obtained almost entirely by breeding them from the larvæ. The moths first bred from larvæ feeding on cotton were unlike those so injurious to the cotton plant in the United States, but later we found another kind, though not in such numbers, which is identical with that of the Southern States. The planters informed me that it was the latter and somewhat larger of these two larvæ that does the greatest damage to cotton in Brazil. Up to the time of our departure from Bonito there were but few of these caterpillars to be found.

Having completed the work at Bonito as nearly as possible in the time at our disposal, we left that place on the 7th of February for Pernambuco, on our way to Bahia, taking with us a collection of insects, which we estimated at about 10,000 specimens.

Between the time of our arrival in the city of Pernambuco and our departure, our time was occupied in arranging our collection for shipment to Washington, and in making preparation for further field work in the province of Bahia.

We arrived at the city of Bahia March 11. As was to be expected, we learned that the cotton-growing part of the province of Bahia was far inland, and that though this port formerly exported large quantities of cotton, there is no export at present, and even the few cotton factories in the province are obliged to import their raw material from Pernambuco, Alagôas and Sergipe.

The Baron of Guahy, President of the Commercial Association, kindly furnished me with the official statistics of the exports of cotton from Bahia since 1862. These statistics show that the exports of cotton from Bahia fell from 7,000,000 kilograms in 1868 to nothing in 1880.

In the commercial reports of one of the leading daily papers of Bahia I noticed the following in regard to cotton, the paper bearing the date of March 14, 1883:

IMPORTS: Cotton, 863 bales from Alagôas and Pernambuco, principally on account of different cotton factories.

Under the head of exports it is remarked:

Cotton: No exports from this province.

Taking such facts into account, the great distance from Bahia to that part of the province in which a little cotton is grown for domestic purposes, the dearness of transportation to such places, and the shortness of the time at our disposal, I thought it best to abandon all thoughts of a trip into the interior. My decision was also strengthened by the

fact that I found that Dr. Antonio de Lacerda, a Brazilian gentleman living at Bahia, and one already well known for his intelligent interest in, and contributions to, entomology, informed me that he had bred a moth from a larva found by himself upon cotton in the suburbs of Bahia. Dr. Lacerda gave me this specimen. It is the same as the larger cotton moth found by us at Bonito, and the same as the one common in the United States.

I hoped, however, that we might be able to find the other moth in the immediate vicinity of the city. With this object in view, we examined all the cotton plants we could find growing about the houses in the suburbs, and were fortunate enough to obtain a number, both of larvæ and of eggs, which being bred, gave us both species of moth found at Bonito. We considered this sufficient evidence of the existence of both species of cotton moth at Bahiá, and made arrangements to stop field-work and leave Bahia at once.

In order to obtain all available publications upon entomology, historical facts and statistics of production and exportation from the whole empire, and also to obtain the indorsement of his Excellency the Minister of Agriculture for the circular I proposed sending out asking for information, I found it necessary to continue my voyage to the capital, at Rio de Janeiro. Arriving in that city on the 29th of March, I prepared at once a circular containing fifty-two questions asking information in regard to the history of cotton culture in the country, the kinds planted, the methods of working and harvesting, the climate and soil found most favorable to it, the diseases and insects that attack it, and the remedies used for such evils; and also concerning oranges, varieties, methods of propagation and cultivation, and the insects and plants injurious to the trees. This circular included inquiries concerning the destructive locusts and concerning the direction of the winds. It was submitted to the Minister of Agriculture for his approval, and he cheerfully indorsed it, and urged those who might receive it to give it their careful attention. Five hundred copies of this circular were printed and sent out through the empire, more especially through those parts of the country where cotton is or has been grown most extensively. The presidents of the provinces of Pernambuco and Maranhão aided me in directing these circulars to planters and other persons who were able to give me intelligent and trustworthy answers.

During my stay in Rio de Janeiro I got together all the information and special reports to be had in the Portuguese language upon entomology. These consisted of a few valuable articles by Fritz Müller, published in the *Archivos* of the National Museum, and a few miscellaneous contributions to be found scattered through old periodicals in the National Library. These latter articles, however, are rather curious than valuable, and could only be had by copying from the books. Through the kindness of Mr. W. T. Gepp I obtained access to the reports and statistics of Brazilian commerce kept by the Commercial Association in Rio de Janeiro, and

was thus enabled to make as complete a table of the exports of cotton from the whole empire as it is possible to obtain. I have arranged these tables so as to show the exports both by years and by provinces, and have reduced the weights, which were originally given in arrobas and kilograms, to pounds. Anything like a complete report of exports can only be had as far back as 1851–'52. From other sources I found that cotton had been exported from Brazil as early as 1760, when 20,833 pounds were shipped from Maranhão. From 1851–'52 to 1875–'76 the total exports from all the provinces reached 1,532,272,075 pounds.

I gathered some trustworthy information in regard to the ravages of the cotton insects in the province of São Paulo, which is the most southerly province in which cotton has been grown successfully, and with it an idea of the percentage of loss caused by these insects in that part of the country.

From the works of M. Mouchez, formerly a lieutenant in the Brazilian navy, and a good authority on the subject, I have obtained a series of charts showing the direction of winds along the northern coast of Brazil for each month in the year. From Maury's data, as furnished me by the United States Hydrographic Office, I have also constructed charts for each month of the year, showing the same thing.

In addition to the reports on winds, already mentioned as having been obtained at Palmares, in the province of Pernambuco, I received from Dr. Draennert, the director of the Imperial Agricultural School at Bahia, a report on the direction of winds at that place, the observations having been made by him, and covering a period of six years. This report includes information in regard to the force of the winds.

Having obtained all the historical and statistical information to be had in Rio de Janeiro upon the subjects which I was directed by you to investigate, and having sent out the circular questions asking for further information on these subjects, I embarked at Rio de Janeiro for New York on the 18th of April, and reached Washington on the 16th of May of the present year.

I have already received a number of valuable replies to the circular and shall doubtless receive others before the report upon my work will have been finished.

I have the honor to be, sir, your obedient servant,

JOHN C. BRANNER,
Special Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

REPORT ON THE EFFECTS OF COLD UPON THE SCALE INSECTS OF THE ORANGE IN FLORIDA.

By Joseph Voyle.

Gainesville, Fla., *December* 10, 1883.

Sir: I have the honor to present the following report of experiments made with cold temperatures on scale insects injurious to orange trees. These experiments were made for the purpose of obtaining some information as to the extent of relief given by frost to infested trees, there being a very general belief that any damages to the tree by frost are fully compensated for by the destruction of injurious insects. Several successive winters with cold of such severity as to, in some cases, seriously damage orange trees, having been followed by heavy swarms of destructive scale insects, gave reason for doubting the truth of the accepted theory. During the past winter, 1882–'83, by some special observations, positive evidence was obtained that often very little damage was done to scale insects by cold that killed the tender orange shoots. On the morning of December 16, 1882, the thermometer was reported at various figures, from 19° to 25° F. My own lowest reading was 25°. On this morning I cut orange branches incrusted with scale insects and found young migratory larvæ of *Mytilaspis* running about quite lively.

By your direction I entered upon a series of experiments that should as nearly as practicable solve the question of "What temperature is fatal to the larvæ and to the eggs of these scale insects?" The laboratory of the East Florida Seminary, with its apparatus, was placed at my service for this work, but fire destroyed the building and contents before the work was begun. It was therefore necessary to devise some inexpensive means of accomplishing the work. The final result of experiments for this purpose was a freezer composed of three tin cylinders of 10 inches, 6 inches, and 2 inches diameter, respectively. The 6 inch was placed within the 10-inch, and by means of a collar both were fastened together and the space between them filled with dry feathers; another collar then fitted on, and all soldered tight. A suitable collar being fitted to both ends of the 2-inch cylinder (which was only 10 inches in length, the others being 14), it was placed within the 6-inch, equidistant from the ends, and soldered tight, thus leaving room for a head 2 inches thick and 6 inches diameter at each end, the heads being packed with dry feathers. Thus was obtained a central chamber within an empty annular chamber, surrounded by another annular chamber filled with a good non-conductor; the central chamber for the speci-

mens and thermometer, the empty annular chamber for the freezing mixture, filled through a short 1¾-inch tube.

Method of using: The specimens and registering maximum and minimum thermometer were placed in the central chamber, the freezing mixture placed in the empty chamber, and the temperature allowed to gradually sink to the desired point, the indices of the thermometer then set to the mercury, and all closed by the heads for the desired time. On opening, the thermometer readings were at once taken and the temperature allowed to rise gradually to that of the atmosphere. The freezing mixture found to be most satisfactory was ice and salt, varied in proportion as required in each case. As will be seen by the table, the larvæ were killed at a temperature above 32° F., and eggs hatched after being subjected to 25° F.

In experiments where, as in these, there is no previous experience to guide the examiner, it is necessary to make various experiments for instruction as to the value of appearances. Sometimes larvæ retain for several days an apparently natural appearance, leaving it doubtful whether their final death is the result of the temperature or want of food. If a small beam of the sun's rays be brought to a focus on the stage of the microscope, the larvæ placed on a slide, the living larva on being brought into the focus of the rays always moves quickly, draws up its sucking tubes, and otherwise shows signs of life, the dead larva showing no motion under the same influence.

The motion of the one is not attributable to heat on inert matter, but to sensibility indicating life, and affords a method of examination before the question of starvation can arise. At moderate temperatures, 30°–32° F., some eggs turn brown and collapse, whilst others, even in the same scale, retain their form and color. This was for a long time unaccountable; at length the brown was found to characterize eggs very near hatching. In experiment No. 10, where some eggs hatched after a temperature of 25° F., out of a large number only three hatched, and of these three only one had strength sufficient to slowly leave the position of the eggs; the others showed life by motion of their legs and antennæ. As a temperature of 19° F. was reported here last winter without clearing off the coccids, a lower temperature was supposed to be necessary, and the first experiments were at 16° F.; then, as results were ascertained, higher and higher until at 24° F. it appeared that the limit was reached. The eggs of *Parlatoria pergandii* and *Mytilaspis citricola* appeared to require a lower temperature for destruction of their vitality than the eggs of *M. gloverii*. Special experiments for this purpose showed that there was only a delay of the changes of appearance, no eggs hatching after a temperature of 24° F. To be practically serviceable, artificial conditions in experiments must approach some form of the natural condition of which information is required. In these experiments the nearest practical approach to nature was taking the insects at the greatest exposure in a still atmosphere. If, then, the temperature

reported, 19° F., be correct, scale insects with only moderate protection should have been killed, and all their eggs with them; but such was not the case. Both thermometers and readings are often questionable. Unreliability of graduation of common instruments, particularly below the temperate figures, and readings made by parties unaccustomed to accuracy, may be taken as a reasonable explanation of wide discrepancies.

There are conditions practically unattainable artificially, where the coccids are protected from the effects of such temperature as under favorable conditions would be fatal to them. The leaves of the tree, the warm current rising from the ground around the trunk of the tree, and the initial heat of the tree itself perform an important part in modifying temperature for these insects. In a still atmosphere this might become a perfect protection against a temperature much lower than would prove fatal in other conditions. Again, a cold, moist breeze following a rain might lower this protection to a fatal point. Casual observation warrants the supposition that these conditions do occur with the results as supposed. Valuable information could be obtained by using registering thermometers within the protection of the head of the tree, and, on the outer branches; a comparison of records would indicate the amount of protection, and give data for ascertaining approximately the amount of cold required to reduce the temperature all over a tree to a point absolutely fatal to coccids: probably a temperature fatal to the tree also.

The table has been arranged from the notes so as to present results without unnecessary details. The experiments were repeated for verification, and also whenever any results were doubtful.

The table may be regarded as an accurate exponent of the effect of low temperature on orange coccids.

Table showing results obtained by exposing orange scale insects to various degrees of cold.

No. of experiment.	Minimum temperature.	Maximum temperature.	Time of exposure.	Result to larvæ.	Result to eggs.	Time from exposure to final result in eggs.	Remarks.
			Hours.			*Days.*	
1	16	24	5	Dead	Dead	31	
2	19	32	10	do	do	12	
3	20	25	10	do	do	4	
4	22	22	5	do	do	7	
5	22	22	3	do	do	12	
6	22	22	1	do	do	14	
7	23	23	1	do	do	14	
8	25	34	10	do	do	20	
9	25	25	5	do	do	12	
10	25	34	16	do	Hatch	8	3 eggs only out of a large number.

Results obtained by exposing orange scale insects, &c.—Continued.

No. of experiment.	Minimum temperature.	Maximum temperature.	Time of exposure.	Result to larvæ.	Result to eggs.	Time from exposure to final collapse of larvæ.	Remarks.
			Hours.			*Days.*	
11	29	29	1	Dead	Hatch	5	
12	29	32	1½	..do	..do	5	
13	29	34	2	..do	..do	6	
14	30	32	16	..do	..do	5	
15	30	32	10	..do	..do	10	
16	32	32	12	..do	..do	10	
17	32	32	5	..do	..do	5	
18	32	34	1½	..do	..do	6	
19	34	34	11	..do	..do	3	
20	34	34	3	..do	..do	3	
21	34	34	2	..do	..do	6	
22	36	36	2	..do	..do	8	

DECEMBER 26, 1883.

During my recent absence from home there was a short period of cold weather, which on my return I found had produced naturally nearly all of the conditions that in my experiments were produced artificially.

Although I was only 10 miles directly south of here, at the place where I was the effects were very slight, and near by there were no traces of frost, tomatoes and bell-peppers out of doors being unhurt.

Had I known in time the extent of the damage elsewhere I could have made some valuable observations.

The thermometer is reported at various figures, ranging from 21° F. to 30° F. The effects show as wide a difference.

In the same neighborhood I find young orange trees killed to the collar at the ground, and orange and lemon trees that are unhurt, and these are sometimes within a few yards of each other.

Six days after the frost, examination showed that the defoliated branches infested by insects were dead, whilst others not so exposed were living, and that where the small twigs were not killed there were some living eggs.

I also find the same appearances as in the experiments, eggs dead and living in the same scale.

The stated probable effects of the initial heat of the tree, &c., are realized and very distinctly marked. I inclose a twig showing this. The outer portion is dead, and the eggs are also dead. The basal portion cut from near the body of the tree is living, and there are also there at this writing some eggs that are clear and pink.

This cold term was calm, the greatest cold of short duration, not more than an hour. The conditions were as nearly a reproduction of those of the experiments, probably, as ever occurs naturally, and the results are so similar as to give greater value to the information artificially obtained.

Respectfully,

JOS. VOYLE.

Prof. C. V. RILEY, *U. S. Entomologist*.

EXTRACTS FROM CORRESPONDENCE.

WATER-PROOF INSECTICIDES.

For years I have been investigating the habits of insects injurious to fruit and vegetables. I find that all insects are more or less susceptible to smells, and their depredations can be largely prevented by the use of some pungent odor. The curculio (*Conotrachelus nenuphar*), for example, can be almost entirely driven from plum-trees by the oil of pennyroyal mixed with lard and rubbed on the branches, or cotton wool saturated with the same and suspended in muslin bags throughout the tree as soon as the first blossoms begin to open. I have never known this to fail, if done in season and thoroughly and at once renewed in case of rain. I have also used to advantage a strong decoction of quassia against the rose-bugs (*Macrodactylus subspinosus*). I have made various successful experiments in this line. I think I have made a faithful test of all the well-known insecticides, and am fully satisfied that when decoctions, tinctures, or emulsions are used, or when the poison can be temporarily held in suspension, the finer the spray the more efficacious appears the remedy. I think there can be no question on this point. A single trial of the tincture of pyrethrum will be sufficient to prove this statement. How far pyrethrum can take the place of Paris green or London purple may still be an open question, or whether refined coal-oil mixed with milk or other ingredients will supply the use of these poisons and be equally effectual without the consequent danger.

In the use of the various liquid insecticides in my experiments I found that their effects were often entirely nullified by exposure to the air, or the material itself was washed off by the first rain. This led me to experiment how to avoid this trouble. An addition of glue and bichromate of potash proved the best remedy. I use from one to two ounces of glue and one-quarter ounce of the bichromate to a gallon of the liquid. The glue should be soaked twenty-four hours in cold water; then dissolved in hot water. The two are to be thoroughly mixed with the liquid insecticide. The application should in every case be made in the form of a minute spray. After the evaporation of the moisture, which takes place in a few minutes, there remains an almost waterproof residuum retaining all its virtues. I believe I have given these experiments a most thorough trial, and that the result has been all that could be desired. There are other chemicals which will produce similar results, but, as far as my experience goes, the above has proved the best.

I think there is hardly any limit to the application of a water-proof insecticide when applied with a proper apparatus.—[WILLIAM PLUMER, *Lexington, Mass., January* 22, 1883.

[We were very glad indeed to receive the full account of Mr. Plumer's experiments with water-proof insecticides. For a number of years past we have been at work at the same point, especially with reference to the Southern cotton-worm, and the latest and most satisfactory results in preventing the washing off of insecticides by rain have been obtained by the perfecting of machinery for spraying the under-sides of the leaves. A long series of experiments with adhesives, such as dextrine, mucilage, gum-arabic, and molasses show that such substances can be used to some considerable advantage, but that this advantage is soon limited by the closing of the stomata of the leaves, thus injuring the plant, and by the interference which they offer to the use of a very fine spray. With Mr. Plumer's particular formula we have not experimented, but we will see that careful trial of it is made next season. His experiments, as given in his letter of the 22d instant, are interesting, but we are rather skeptical as to the use of pennyroyal for the curculio, as we have always found that this insect was very slightly affected by malodorants, and it is so easy to mistake a natural disappearance for the result of a remedy.]

DESTRUCTION OF SCALE INSECTS BY COLD.

* * * I mail you with this a piece of orange branch covered with *Mytilaspis* that has been submitted to a temperature lower than usually, if ever, occurs in this State. It was first placed in the chamber of the glacier at atmospheric temperature 82° F., and the temperature gradually lowered to 42° during one hour; then the cooling was forced, and left for four hours, when the reading was 24°. The indices were then brought to contact, the chamber closed, the cooling forced, and then left for twelve hours. At the end of that time the chamber was opened, and the maximum immediately read, being 30°. The minimum index read 16°. Therefore, after cooling for five hours, the coccids were subjected for twelve hours to a temperature commencing with 24° F., descending to 16°, and not rising above 30°. A microscopic examination was immediately made. No sign of life was found in the larvæ examined. The eggs appeared natural. After drying in the atmosphere the forms of many of the larvæ appeared shrunken; some eggs had collapsed, leaving white forms; others retain, after twenty-four hours, their usual form. They will be examined from day to day, to see if any of them can bear the treatment, and hatch, so as to be a guide for the next freezing. * * * —[JOS. VOYLE, *Gainesville, Fla., May* 15, 1883.

[A careful examination of the scales received failed to show any live eggs.]

A PINE SAW-FLY FROM ARKANSAS.

I send you specimens of the pine worm of which you have received mention. They are fast disappearing, but a great many of the largest trees are completely stripped of their foliage, and the sign of their ravages is visible on every tree and bush. I have never noticed but one instance where they had eaten any other tree than the pine, and that was a small ash on which a few had lodged in falling from a tree after defoliating it. The leaves of the ash had been eaten to a slight extent. They never touch the new growth, but confine themselves entirely to the growth of last year. * * * —[W. A. MOSELEY, *Camden, Ark.*, *May* 4, 1883.

[The pine worm proved to be the undescribed larva of a saw fly of the genus *Lophyrus*. These insects undergo their transformation to pupæ in silken cocoons on the surface of the ground, among the leaves and other rubbish; hence burning over the surface of the ground in winter, where it is possible, will be a good remedy. Ornamental trees can be preserved from their attacks by syringing them with hellebore water or Paris green water.]

SAW-FLY LARVÆ ON WHEAT HEADS.

I have as fine a field of wheat as I have seen this season. This morning, in looking over it, I find upon the heads quite a number of such worms as are here inclosed. They take a portion of the grains out of the heads they attack. They are not very numerous, perhaps three or four in a rod square. I am at a loss to know what they are, or whether they will materially injure our wheat. My neighbors also have them. Will you please inspect them?—[J. C. HOSTETTER, *Minerva*, *Ohio*, *June* 16, 1883.

Your favor of 21st instant is at hand; also mailing box and stamps.

I have just returned from a walk around a twenty-acre field of wheat. My object was to pick off a dozen or more of those worms to send you. To my utter surprise (though making diligent search) I found but three, one of which I lost on my way to the house. Only a week ago I could have found any number of them in the same field. They are now gone, having either dropped off, or been taken by the birds, or both. Please pardon me, therefore, for sending only those two discoveries for inspection. If I find more I will send again. I think these are full size, or nearly. I found them on small heads of wheat, the same inclosed. You are evidently clearly right in saying we need not apprehend much damage from them. Their time is of short duration and seems to be confined to the period soon after the wheat is in head. I don't think they affect the kernels when fully formed.—[J. C. HOSTETTER, *Minerva, Ohio*, *June* 25, 1883.

The larva above mentioned was that of a species of saw-fly (family *Tenthredinidæ*). We sent for a number of additional specimens in order to endeavor to obtain the mature insect, for we did not recall any record of injury to wheat by a *Tenthredinid* in this country. Curtis gives an account of one in Europe, the description of which agrees very closely with this larva, but from his account it would seem to have come from some neighboring woods and not to have been naturally feeding on wheat. As many of the saw-fly larvæ, when abundant, have a habit of wandering from their original food-plants, such may have been the case in this instance. We endeavored to get positive evidence of its wheat-feeding habits, but failed, and the larvæ received from Mr. Hostetter died before transforming, so that the species was not even ascertained. The same larva was reported by W. S. Chamberlain, Secretary of the State Board of Agriculture, as occurring on wheat at Columbus, Ohio.]

TINEID MOTHS IN DRIED FUNGI.

Please allow me the privilege of sending you a specimen of my collection of fungi and their foe, and, if not too much trouble, please tell me the name of the insect. These fungi were put in a strong paper box and tightly wrapped in three folds of paper and tied with twine to prevent the moths from depositing on them their eggs. It seems that the larvæ bored through paper and box and gained access to them. Corrosive sublimate, &c., does not appear to protect them unless *saturated*. The only way I have succeeded in saving specimens is to put them in tight boxes with a sponge saturated with chloroform.

I sent you specimens once before. You wrote me you thought them new. Your final answer is given in *American Entomologist*, vol. 3, p. 297—*Cis fuscipes* Mell. Evidently a mistake has in some way happened.—[J. J. BROWN, M. D., *Sheboygan*, *Wis.*, *May* 15, 1883.

[The moth proved to be *Scardia cloacella*, Haw., allied to the common grain moth. There was no mistake about *Cis fuscipes*. Both species were received, and both infest the fungi.]

THE APPLE MAGGOT.

* * * In regard to the apple maggot, I can say that with us it is a pest equal if not exceeding the Codlin moth (or its larva). It attacks both early and winter fruit, greenings and Baldwins seeming to be its choice, sometimes, yes often, completely honey-combing the fruit. We have fed out quantities of apples infested with this maggot.—[S. E. FRISBIE, *Milford*, *Conn.*, *March* 15, 1883.

Your very obliging letter, acknowledging receipt of the Dynastes pupa, should have been noticed sooner, but I wanted to find some memoran-

RHINOCEROS BEETLE—SAND BEE—CATTLE TICK.

dum of what I now suppose was a rare opportunity to have studied this beetle. None is to be found. I am ashamed to own it, and to offer my memory of what occurred years ago. In fact, at the time, I noticed such things merely for my passing pleasure, without the least notion of interesting the world. It was as I mentioned: In March of 1868, a large post-oak tree I had cut for rails, posts, and wood, was found hollow at the top; the cavity some 10 feet long, and branching into the larger limbs, by 12 inches in diameter. I do not recollect seeing any large opening into the cavity. There were small holes, such as might have been made by woodpeckers and squirrels. Within, the trunk contained no nests of birds or other animals, but some decaying acorn hulls, sticks, and leaves. The lower half contained a black, damp mass of decaying vegetable matter, rotten wood and fungi. In this rotten and decaying mass were numbers of grubs, evidently grubs of beetles, and in size from 1 inch to 4 in length; at the top, in looser, drier matter, were several pupæ, and amongst the old sticks and leaves numbers of perfect beetles, most of them dead and in pieces, but a few still alive. * * *

I send you a small tin box containing the nest of a sand bee of some kind. There were four cells originally, as plowed up in a cotton field 6 miles northeast of Selma, but the curiosity of a companion destroyed two of them before I was aware. A more curious thing, also, in the box—unless you have seen the same before—is a large tick laying her eggs. On the 10th of March the tick was found, full of blood, at the foot of a bank, where a cow had recently rubbed it off after carrying it all winter. I placed it in a box, with loose cotton on top. Two weeks later, looking at it, I found it had shrunken to half its original size, and the first mass of eggs was extruded. It should have been sent you then, but I was busy about other things and it was overlooked. Now, after eighteen days, it has continued to lay, and another mass is hanging to it, whilst the skin seems shrunken very much.—[LAWRENCE C. JOHNSON, *Selma*, *Ala.*, *April* 20, 1883.

[The nest of the "sand bee" was that of a species of *Osmia*, and the tick was the common *Ixodes bovis*.]

THE SCREW WORM.

Permit me to call your attention to the Texas "Screw Worm," which was very troublesome to stock in Kansas last year. I am medically informed it is the *Sarcophaga georgina*. I send you a larval specimen. It kills a great many animals and some people. Neglected babies, children, and adults with nasal catarrh are sometimes afflicted and killed by it. We are told that it flies into the nose of a man the same as the bot-fly in the nostrils of a sheep, and lays its eggs or young. In animals a wound or blood attracts it. Calomel, chloroform, and carbolic

acid kill it. I shall blow dry calomel up a patient's nose or ear that is attacked when I treat it. It is said to prefer the dog and sheep for victims.

Hope we may see some facts published in next Agricultural Report about it, and oblige 10,000 Kansas farmers and stockmen, &c.—[W. S. NEWLON, *Oswego*, *Kans.*, *March* 30, 1883.

[The larva was that of *Lucilia macellaria.*]

JUNE BUGS AND PEAR-LEAF MITES.

The "West Town Farm and Garden Club," at its meeting last Saturday evening, had two items before it, among others, which it wishes to refer to you for information.

The first regards a swarm of bugs that in large numbers at night are eating the foliage of the fruit trees on one or two neighboring farms. They are evidently a species of June bug, or May beetle, as some of the latter were found on the tree the smaller ones were taken from, one of which is inclosed with the smaller bugs.

The other item may not come in your department. If not, please have it put in the right hands.

A member brought in a branch of a pear tree, a twig of which is inclosed. The tree appeared perfectly healthy up to the time of its attack, when in twenty-four hours the leaves were all affected more or less as the sample inclosed. The club would like to know the nature of the disease, and the remedy, if any, for it; whether it is likely to be fatal, or contagious to neighboring trees.—[JAS. B. FISHER, *President*, *West Town*, *Orange County*, *N. Y.*, *May* 21, 1883.

[The "June bug" eating the foliage of the fruit trees was *Lachnosterna tristis.* The best remedy will be found in attracting them at night by a light suspended over a tub of water on which is a thin scum of kerosene.

The diseased appearance of the pear leaves sent was caused by one of the gall mites—probably *Typhlodromus pyri.* We advised that the tree be sprayed with one of the kerosene emulsions spoken of in the Annual Report of this Department for 1881–2, pp. 115 and 116.]

THE GRAPE-VINE COLASPIS.

I send you some bugs in a vial. Please tell me what they are, and if there is any way to kill them or prevent them from eating up grape-vines and young grapes. Three years ago I planted out 75 acres in grapes, mostly Scuppernong variety, but some of all kinds. Last year these

bugs made their appearance in countless numbers, but I caught them in a cloth; but this year the vines are too large, and I tried several remedies and none will move them. Please inform me as soon as possible if you know of anything, and greatly benefit, yours, respectfully.—[JOSEPH A. HARPER, *Blackshear, Ga., May* 10, 1883.

[The beetle injuring the grape-vines proved to be the Grape-vine Colaspis (*Colaspis brunnea* Fabr.), treated in our Third Missouri Report, p. 81. The larvæ feed on the roots of plants, and often do considerable damage to strawberry plants. The best remedies found are in jarring them into sheets saturated with kerosene, and in spraying the vines with a Paris green or London purple solution in the proportion of 2 ounces of the poison to 10 gallons of water, thoroughly stirred.]

I have a vineyard of about 800 plants, of twenty or twenty-five different home varieties. It is in its fourth year on the ground, and up to the 12th ultimo looked perfectly beautiful and of a luxuriant growth, whilst the vines were almost all loaded with fruit of excellent form and size. An insect has since made its appearance in myriads and myriads, and perforated the leaves in such a way as to cause their becoming dry and falling. It attacked almost all varieties, less in some way the Concord, although the leaves are fearfully damaged. The grapes, thus far, lost none of their vigor, owing perhaps to wet weather, which, unfortunately, troubles us for all other crops very much.

In a separate parcel I send you some insects of the above. Please examine them, and let me know their history, and if there is any chance of a remedy for their destruction before they destroy our crop. Last year, too, we were troubled by the same pests, but to a smaller degree. If my statement is any way obscure, please call it to my attention that I may furnish you with further information. Our Scuppernongs are not damaged, but many weeds with large leaves, such as docks, are perfectly perforated, the same as our grape-vines.—[C. MENELAS, *Brookhaven, Miss., July* 6, 1883.

[This was same insect and the same advice was sent.]

STRAWBERRY FRUIT BEETLES.

Inclosed you will find some insects which have proved very destructive to my strawberries. I have only 400 plants in my garden, and last year should have been their best bearing year; but the crop was entirely destroyed by these insects. They came as the berries commenced turning, and we had very few to ripen, as they ate small holes in them, and then the whole berry became soft. I salted the vines when they were done bearing last year, thinking it might kill the bugs for this year. And I thought I had succeeded, as we gathered a splendid crop

of berries before the bugs came; but the last week of bearing the crop was again destroyed by the same insect.

Is it a new plague, or has it been known before, and can you tell me what it is, and what will prevent its ravages in the future?—[Mrs. GEO. SCHALL, *North Wales, Montgomery County, Pennsylvania, July* 4, 1883.

[The insect accompanying this letter, and which was said to injure strawberries, was a common beetle known as *Stelidota strigosa*, Schön. It has never been recorded as doing any appreciable damage to any crop before. It feeds ordinarily upon fallen fruit, in which the female also lays her eggs. The larva attains its full growth in a short time, and the beetle issues in late summer and hibernates in this state. With regard to remedies, it will be difficult to advise. Feeding on the fruit as it does, the ordinary poisons cannot be used. The insects and their breeding habits should be carefully studied on the spot; in this way a remedy can doubtless be found.]

GREEN SOLDIER-BUG (RAPHIGASTER HILARIS) ON ORANGE TREES.

* * * You also request observations on the Green Soldier-bug. I forward by same mail twigs of the orange tree injured by the bug. The insects are coupling now. The females will soon lay the eggs in a cluster on a leaf, straddling over them while laying. The young appear in the latter part of February or the first part of March. As observed by the eye the young are black, with white spots, which color they retain until nearly full grown, when they acquire wings and change to a bright green. How this is done I do not know. They mature very quickly, and increase with surprising rapidity, continuing to breed until November. In the spring and early summer they confine their attacks principally to garden vegetables and succulent weeds. They are particularly abundant on tomato-vines, egg-plants, turnip-tops, and mustard, seldom doing much damage to orange trees at this season. When pea-vines are well grown, about or a little before the time of blossoming, they abandon nearly everything for the pea-vines. Last year they totally destroyed my garden. Not one tomato came to perfection. Where the insect had inserted its sucking-tube a reddish-yellow spot appeared. When cut the fruit was full of lumps and totally devoid of flavor. The tomato-vines grew so enormous a crop that the ground was almost covered by the fallen fruit. Last year I had 35 acres planted in cow-pea vines, which bore an enormous crop of peas; but not enough sound peas could be gathered to plant 5 acres additional land. Later it was impossible to find a sound pea. I attempted to turn under the vines, but so luxuriant was the growth that it could not be done. Towards the end of August the pea-vines were dead or dying, when the bugs swarmed to the orange tree, killing nearly all the

new growth. Immense numbers were killed by keeping men constantly going over the grove, shaking the trees, and killing all that fell on the ground. The wingless individuals were readily killed, but the larger number of the mature insects saved themselves by flight. This method of destruction was kept up until the middle of December, by which time very few were found. On very cold days the winged insects were nearly dormant and could not fly. I have the trees frequently searched now, but rarely find the bug. The number of the insects is incredible. When thoroughly shaken, the ground under the trees would be alive with the fallen insects, and two days later just as many would be found. I despaired of getting rid of them until the cold weather commenced, when I found the number rapidly decrease until their nearly total extinction.

As to the damage. The bug first attacks the latest growth, which wilts and droops while the bug is sucking; in a few days the shoot is dead; the same eye soon sends out another shoot which shares the fate of its predecessor, and so on until the eye has the appearance of a large bunch, as you will see on twigs sent. After all the tender growth has been destroyed the bug inserts his sharp sucking tube in the previous growth which has nearly hardened. Here I can only give you the facts and my theory; it is a fact that the insect sucks such wood, but the damage does not follow so quickly; but very soon after, on such wood known to be sucked, numerous bumps appear, which crack and exude a sticky sap, white at first, but soon a rusty red, and hard. Later on the insects suck the juice from fully-matured wood (an inch or more in diameter); on this wood the bumps do not appear, but the same kind of sticky sap exudes in tears, which soon harden and redden and are what I understand by "red rust." That the cause and effect are strictly true I can only surmise, but this much I and my men have seen: the insects sucking the sap as stated and the branches where sucked having the appearance described. In the winter months I have found clusters of the bugs on the stocks of the buds, two inches in diameter, and always an exudation of sap at these places, which I have never observed to redden as in the instances stated above. Why this is so, and why the insect leaves the more tender bud above to suck the sap from harder wood nearer the roots, I can offer no suggestion. At first I was strongly inclined to think that red rust was caused by soil-poisoning, but if so, why is it that trees have grown for many years on the same soil and never had this disease until the introduction of the Green Bug? To illustrate: When I bought this place ten years ago there was a field of five acres which had been in partial cultivation several years, and on which grew spontaneously the tomato and mustard plant, the two plants on which the insects thrive the best. (At present I can only find the insect on the mustard.) Since my purchase I have kept this field constantly growing pea-vines, as well as the forty other acres which I have in orange trees, thus giving every encouragement to the in-

crease of the pest. Adjoining this old field was a wild orange grove in a dense forest. Many of the sour stumps had large sweet buds, neither the buds nor sour trees giving any signs of the red rust until the winter following the clearing, and after a crop of pea-vines had been grown among the trees. Now the trees in this wild grove are just as much damaged as in the old field adjoining. Another case I will mention, and not trespass further on your patience. Five miles distant is the grove of L. Merritt, a wild grove budded. The buds are six years old and ought to be bearing heavy crops, but an occasional bloom is all. The trees have been in an unhealthy and "die back" condition for several years. When visiting his grove in the fall of 1881, I told him I had some trees in the same condition and was inclined to think the Green Bug was the cause. Since that time he has persistently hunted the bug, whipping it out of the large trees with poles, and killing wherever found; also he stopped planting peas. I have just visited his grove and found but two twigs damaged, and could not find a specimen of the bug. The trees have changed so remarkably in this grove that it was past recognition. Instead of a dense crop of dead twigs all over his grove, as at a previous visit, the trees had nearly doubled in size, and had a very large, healthy growth of branches in place of the dead twigs. I hear his trees are now in profuse bloom. I do not think that washes will do much damage to the bug. Very strong whale-oil soap rarely kills. Whale-oil soap, 1 pound; kerosene oil, 1 pint; water, 12 pints; sometimes kills when sprayed over them, nearly always when immersed. Pure kerosene kills, but not always instantly.

The Green Bug has a parasite. I do not know what, but I frequently find their shells with the inside devoured. Last winter I buried a number to see if plowing under would kill them. In ten days none were dead; in three weeks 20 per cent. were dead, nothing remaining but the shells; in six weeks all but one were dead, empty shells remaining. The living insect I put in a bottle with a little earth over it, hoping to find the parasite, but unfortunately in about ten days the bottle was broken, the Green Bug was dead, the empty shell as in the other instances.

At present the insect is very rare here; if found at all, generally on the mustard plant or a weed locally known as nightshade. Yesterday, while showing a lemon tree to some visitors, I found some of the twigs drooping and remarked it looked like the work of the Green Bug. One was found under a leaf close to his work. I send you one of the shoots. If at any time you may consider the subject of sufficient importance to send a trained observer in the field, I will be happy to see him here and place every facility at his disposal.

With apologies for the length of my letter.—[JAMES FRANKLIN, *West Apopka, Fla., January* 31, 1883.

THE APPLE TREE PLANT-LOUSE.

Could you make it convenient to tell me the name of the inclosed Aphides? This is fruit year for the apples of Monmouth County, New Jersey, and the trees are almost-black on the flower buds with these lice. The farmers are filled with apprehensions. Last night was a black frost, and it bids fair to be so to-night. But I find that, though numb on the trees to-day, they became quite lively when brought into the house. What do you think about them? Is it usual so early? Any information will be gratefully received.

P. S.—Just after making up the package my son brought me some buds of Bartlett pears similarly attacked. I opened the package and put them in. They are inclosed in tinfoil, thus separating them from the others.—[SAMUEL LOCKWOOD, *Freehold, N. J., April* 25, 1883.

[The louse was the common *Aphis mali*, and it is not at all unusual to find them in such numbers thus early in the season. As a remedy we advised trying a very dilute kerosene emulsion, as described in our last Report for 1881–2, pages 112–116.]

OAK BARK-LICE.

With this note I send you portions of an oak twig (*Quercus aquatica*) which are incrusted with scales or galls, or whatever you may term them. The branch looks barnacled.

I do not remember ever having seen them before. The oak from which they came is growing on the roadside, and is about 15 feet high. The twig or young branch seems to have been twisted by some driver who wanted a switch, but who did not succeed in wringing it off. It is (as you will see from the young leaves) still growing, and upon this twig *only* were found the insect scales. Nowhere else on the tree are they to be seen—only on this hanging and twisted branch.—[J. H. MELLICHAMP, *Bluffton, S. C., April* 23, 1883.

[The bark-lice belonged to an undescribed species of the true genus *Lecanium*. The fact that they were found on the broken twig is of great interest, as bearing on the preference which all bark-lice seem to have for enfeebled trees and portions of trees.]

CATTLE TICK ON HUMAN BODY.

This tick was removed by a friend of mine—a physician—from the border of the arm-pit of a young lady. The tick had penetrated so deeply that it was removed with some difficulty without breaking it in

pieces. As far as I can ascertain by consulting Packard's Guide, I guess it may be a species of *Ixodes*. Is it a common pest?—[H. C. BEARDSLEE, *Painesville, Ohio, July* 1, 1883.

[The tick was a variety of *Ixodes bovis*.]

ORANGE RUST MITE, MEALY BUG, AND TAP-ROOT DISEASE.

Having business near Orange Lake during the past week, I visited several orange groves. I found all of the Florida varieties of scale-insects in abundance. Oranges are already rusty, and the rust mite in many places, on both leaves and fruit, in such large numbers as to give a distinct coloration, distinguishable at a distance of ten feet.

But the most destructive insect, at present absorbing all the attention of the orange-growers there, is the mealy bug, *Dactylopius destructor*. This insect causes the fruit to rot under the colonies. A favorite place of lodgment is at the stem, under the calyx; the result is, the fruit drops.

I staid there three days to examine methods used and experiment in their destruction.

The cottony armor repels all watery solutions.

The methods used are: spraying each separate colony with pure kerosene by means of bellows atomizers; and mechanical action—rubbing or pinching each separate colony (by colony I mean the little clusters consisting of from ten to several hundred individuals); this is done by the fingers.

I examined the trees that had been treated with the kerosene spray and found both the leaves and fruit spotted yellow. I was also informed that fruit saved in this way two years ago was useless, having absorbed the odor of kerosene. The effective progress made by the means used is trifling, in consideration of the work to be done. I tried experiments with solutions of murvite, sprayed on, but with no good result; then tried kerosene butter, using thick, milky solution of murvite, which combines in exactly the same way as with cow's milk, and found that an effective emulsion could thus be made.

After using and watching the action of this for some time, I saw that the interior insects of a dense mass were protected by the exterior ones; further experiments were made to meet this difficulty. By watching the men at work I saw that nearly every infested orange was handled to turn all of its sides to the eye; that wherever a large colony found lodgment in a fork of twigs or in a depression of the bark they were handled, also that the bunches of Spanish moss (*Tillandsia*) formed formidable breeding places. All of these require force for their dislodgment.

A strong stream of water was tried and proved effective, but laborious, and the insects falling to the ground were not killed.

Experiments with solution of murvite, made under a microscope, showed that in all cases where the solution came into actual contact with the skin of the insect the bug was instantly killed. Acting upon this and the knowledge gained by previous observation and experiment, I tried the effect of a fine, solid stream issuing under pressure, using a solution of murvite, one part, to water two hundred and fifty parts. The results were excellent; the solution being forced into the colonies broke them up, and coming into contact with the insects killed them, the method of working being one man at the pump, another to guide the stream. The apparatus improvised being badly adapted to the purpose is very awkward. The work, although about four times as fast as with the bellows atomizer, is not adequate to the economical requirements. This method has the merit of no loss by damage to fruit or leaves by the material used; the waste, falling on the leaves and branches, will exterminate both scale insects and rust mites, these being plentiful, but neglected in the presence of the more pressing necessity of saving the growing crop from destruction by the mealy bug.

Business required my presence at home, so I was obliged to leave. As I can do so, I will try to fit up an apparatus adapted to this work. Having none of the insects here, or, as far as I know, nearer than the ake, twenty miles distant, I cannot make any experiments at home as I would like to do.

At Micanopy I found several large trees dying slowly from some unseen cause. Some time ago I induced one person to dig under the lateral roots and examine the tap root of a tree in a similar condition; result, bark of tap root not all rotten. I was not present to examine it. The tree being large and yielding well, the owners generally prefer to take the chance of recovery to any act that may expose the roots and increase the damage; but the matter is important and statements are confused; some say that a white worm causes it; others, white ants; others, wood lice. I have found trees damaged by each of them, but they differ from the causes at Micanopy. I have heard of its being serious at other places.

Can you advise me of the best means of proceeding, what to look for, and how to look for it, so that if I have opportunity I may intelligently search into the matter?—[JOS. VOYLE, *Gainesville*, *Fla.*, *June* 12, 1883.

[This disease of the larger trees is supposed by Mr. Hubbard and others to be caused by the tap-root reaching water and decaying in consequence.]

Miscellaneous Observations.

The larva of the *Papilio cresphontes* has, to me, a new enemy. So few enemies has it, from its smell, no doubt, that no birds attack it, though often exposed. The shrike, that is almost omnivorous, will not touch it, nor will the bee martin, nor the mocking bird. The Tachina fly is only occasionally a parasite. The Mutilla (cow ant) this year has nearly cleared my trees of the *cresphontes*; it snips out a piece from the abdominal ring, takes a sip of the fluid, and then the "sugar-ants" finish the work. By the way, these "sugar-ants"—small, yellow fellows—are pests invading the cupboard, getting into meat, sugar, &c. I find their nests in rotten wood, in roofs, logs, &c. They are nearly as bad as the cockroach, and this last ought to be named "*Omnivora periplaneta.*" Pyrethrum has but little effect on the roach here.

I made a "grand round" lately to see the effect of my experiments with kerosene last year.

In Bulletin No. 1, pp. 17, 18, Professor Hubbard states that a five per cent. kerosene emulsion did not prove satisfactory, and that by next spring Dr. Neal would have considerably modified his conclusion. Of course, if the facts proved me wrong, I would, but they do not.

Experiment 1. Made at Judge J. F. McDonell's, 5 miles south of me—trees 12–32 years old, badly affected. June 1, 1883; trees growing well and clear of the old scale. The most of the leaves dropped, but a new growth soon took their place.

3. Two miles southeast of Archer. Examined in October and November: no scale on the new growth of leaves; none June 1, except when trees affected had been set in proximity.

10. Five miles south. The owner reports, "trees in good order; no scale on the trees you worked on."

From what I have seen, I can see no reason to modify the conclusion on p. 34, though I believe it most economical of time and money to buy and use "Bonnetheau's" emulsion, made at Jacksonville. Then a compound of kerosene, petroleum, tobacco, potash, &c., is cheap and easily used. Two two and one-half per cent. applications, one in March and one in June, do good work. Dr. Todd, of Lawtey, Fla., has used "crude petroleum," made up a la kerosene 5 per cent. emulsion, and likes it better than kerosene or creosote.

Who has tried "oil of tansy"? A few experiments I have made indicate that in most cases it is a grand insecticide, and added to kerosene emulsion doubles its efficacy. The proportion I have not yet determined. It could be very easily obtained, as probably an infusion would answer.

There is a general abeyance of insects this year; very few of the Heliothis in corn or tomato; no cotton worms yet found, and no Dysdercus reported. Even the Plusia and Agrotis are not plentiful. Result of the warm February? * * * [J. C. Neal, M. D., *Archer*, *Fla.*, *July* 3, 1883.

ANOTHER EAST INDIAN COTTON WORM REMEDY.

With regard to sending to your Department specimens of insects which injure the cotton crop in Burma, I regret I cannot do it at once, as most of the cotton fields in Burma have been left waste for the last two or three years, on account of disturbances between the king of Burma and Shan chiefs. At such times the cultivators are not safe, being every now and then attacked by the enemy and looted, but I will keep in mind, and will endeavor as soon as an opportunity is offered to procure the specimens of injurious insects which attack the cotton and forward the same to you as desired.

I will send you shortly another remedy for injurious insects; it is the bark of a tree that natives soak in a jar of water for twenty-four hours, after which the water is sprinkled on the plants. I am told that by such process insects are killed, and the smell of the water on the plants prevents them going near to the plants any further. I shall send the seed also with the bark, that on trial of the experiment, if successful, you may try the seed for growing the tree.—[C. LUCAS, *Rangoon, Burma, January* 29, 1883.

POSSIBLE NORTHERN FOOD-PLANT OF ALETIA.

Referring to mine of 17th ultimo, and in reply to yours of 13th instant, I regret to state that the larva unknown described to you as feeding on *Hibiscus trionum*, disappeared during the night of the 23d ultimo, before which time I had discovered two similar, save a black dorsal line, each upon flower spike of *Lupinus pilosus*. A drawing was sent to the Entomological Society of Ontario, and a description. I have to state that larvæ similar in size and color to Figs. 4 and 5 of Plates V and VI, page 348, Agricultural Report for 1879, were seen by me in my garden at Riverside in August of 1879—supposition, from eggs attached to botanical débris obtained near Washington, perhaps leaves and fruit of *Callirrhoë pedata* obtained from back of Mr. Gray's, 204 Seventh street southwest—crawling upon and imbedded in plants of *Gnaphalium uliginosum* L. (Marsh Cudweed), a common weed in this district, *i. e.*, Riverside. I sent you a specimen of the plant from my garden.—[ALFRED H. MOORE, *Toronto, Ont., October* 19, 1883.

PARIA ATERRIMA INJURING STRAWBERRIES.

I sent you some larvæ of the strawberry crown-borer in a potato this morning. I have a few more now and will send them the same way, except that I will inclose some damp soil with them. I think they do not eat now, for I find them in a little cavity in the earth, not far from the surface. I have been acquainted with this pest for ten years, and I re-

ceive plants from all parts of the country that have been injured by it. The injury it does by boring into the crown is as nothing compared with what it does to the roots, eating off the bark and fine roots. Soon after the roots are injured the leaves get rusty and finally die. The inner leaves lose their glossy and healthy appearance. Where they are plenty they will injure the roots of young runners almost as fast as new plants are formed. It is common to find a runner with four or five plants, the oldest of which will have its roots ruined, the next two more or less damaged, and the youngest uninjured. Plants set in spring to be grown in hills wil flourish till July, or August, then send out weak, slender runners, commence to rust, and almost die. These larvæ never bore down the center of the crown, but down and part way around the outside and some times horizontally into the center. I am not sure it is the crown-borer at all. A few years ago I received plants from Dimondale, Mich., where Professor Cook first saw the strawberry-root worm. If this is it I have had it ten years in this town. The plants I speak of were greatly injured the first season, so that I had to remove them. As soon as I see a bed where this pest is at work I can tell by the rusty, sickly appearance of the foliage.

There is another worm that damages my plants to a great extent, but it is not confined to the strawberry. It eats potatoes, carrots, or any roots, and is very fond of celery. When it works on strawberries the foliage is apt to lose its dark glossy green look, and become almost variegated, yellow and green. The leaves do not attain their full size, and have a warped appearance, like a thin piece of steel made red hot and thrown into water. These worms are about three-fourths of an inch in length, not thicker than a pin, brown color, with many legs, and almost as hard as wire. Early in the spring I find many without legs, almost white, and less lively than the ones I describe.

Many of my plants are perforated by a little bug or beetle about one-fourth of an inch long, in shape resembling a striped cucumber bug, and of a dull yellowish color. I saw plenty of them two months ago, making holes in the tenderest leaves, and now I see many of their holes. Is it the crown-borer?

I would like to know where the eggs of these larvæ are laid. I have found that young plants taken up in July and washed clean and planted in a new bed are sometimes badly injured the same fall, but cannot tell whether the eggs were attached to them or not.—[M. CRAWFORD, *Cuyahoga Falls, Ohio, October* 9, 1883.

[The larvæ were not those of the Strawberry Crown-borer (*Analcis fragariæ*), but belonged to a little beetle known as *Paria aterrima*, the same species mentioned by Professor Cook in his address before the Ingham County Horticultural Society, and described in the *American Entomologist* for October, 1880. The other worm mentioned and which was not confined to strawberries, was the common *Iulus multistriatus*, one of the commonest of the "thousand-legged worms."]

THE ELM-LEAF BEETLE.

Galeruca xanthomelæna came in great force in June, and defoliated all our beautiful elms, to the great injury of our village. In the third week of July the trees all put forth a new crop of leaves, about one-third the size of the first crop. In the fourth week of July the second brood of *Galeruca* came, and devoured the new leaves. We are all anxious to see whether the trees will stand this treatment next spring. I fear our fine elms here are all doomed.—[REV. SAMUEL LOCKWOOD, *Freehold*, *N. J.*, *August* 6, 1883.

GRAPE PEST—CODLING MOTH.

I send you to-day a beetle which you will confer a favor by determining at your earliest convenience. You will remember I sent you a *Blapstinus* said to be destroying foliage of grape-vines. Now here is another Tenebrionid that in one case has destroyed 35 acres of grape-vine. (Further particulars soon.) I also send you a codling moth I raised from a pear four years ago. I found quite a number last year. Is this a different species from *Carpocapsa pomonella*, or only a variety? The specimen is in vial.—[MATTHEW COOKE, *Sacramento*, *Cal.*, *July* 23, 1883.

[The Tenebrionid sent was *Eleodes quadricollis* Lec.; a very numerous species in the more northern part of California. The species of that genus, so numerous and abundant in the region west of the Rocky Mountains, are all known to feed upon decaying vegetable matter, and none have hitherto been reported as doing damage to cultivated plants. In fact, this communication, if correct, would indicate a change of habit hitherto unprecedented in the history of economic entomology, and, unless further proof be brought forth, we can hardly believe that the species referred to is the real author of the damage to grape-vines. The only species of the large family *Tenebrionidæ* which can be considered as injurious are those feeding on stored produce, *e. g.*, *Tenebrio molitor*, *T. obscurus*, *Tribolium ferrugineum*, *Gnathocerus cornutus*, and a few others.

The codling moth was an interesting variety of *Carpocapsa pomonella*, with obsolete maculation.]

THE WHEAT MIDGE.

I find that I have fallen into the error of using a name for the wheat pest that is in erroneous use here (*weevil*). The one I mean is called in Ontario the midge. It comes out in the fly state in July, and deposits its eggs near the kernels when the wheat is in its early stage. The yellow grubs live upon the wheat in its milky state and leave it shriveled and worthless. When we get a very early season, as this is, the wheat

sown before the 1st of May matures earlier and escapes to a great extent. Last year the wheat sown on the 16th of June got very well clear, but that sown from the 5th to last of May was severely handled by the midge. I shall be glad if you can give me any information as to the best means of getting rid of the pest. I have no doubt you are well acquainted with its habits and have often referred to it in your reports. If you wish I will collect and forward samples of eggs in season.—[WM. HEARD, *The Cedars, Prince Edward's Island, April* 23, 1883.

[The insect spoken of in this letter was, without doubt, the Wheat Midge (*Diplosis tritici*, Kirby). It has done but little damage in the United States for the last twenty years, and we have not had occasion to study it particularly, nor have there been any articles of importance published about it since Dr. Fitch's lengthy summary in the Transactions of the New York State Agricultural Society for 1860. This is the best account of the midge ever published. Another excellent account is found in Harris's Insects Injurious to Vegetation. We sent for further specimens and received the following reply:]

In accordance with the request contained in your favor of 28th April last, I now forward by mail some specimens of wheat midge, which are in good condition for investigation. This year we would have had a magnificent return but for the depredations of this insect. In some districts the loss is total. Late-sown wheat has so far escaped. Perhaps this may be found the only safe plan, but the risk of bad weather in September for harvest induces many to run the risk of early sowing. * * * [WM. HEARD, *The Cedars, Prince Edward's Island, August* 22, 1883.

MAMESTRA PICTA EATING PEA VINES.

A little worm is eating our pea vines. Not having noticed it before, I thought I would send you a few specimens for determination. I send them in a small box by this mail. If not too much trouble, please tell me the name, and if it is common. Have found it on only one or two plants, but these plants were covered and entirely destroyed.—[F. H. HORSFORD, *Charlotte, Vt., June* 30, 1883.

[These specimens were in poor condition and unrecognizable, and more were sent for, which were received together with the following letter:]

Yours of the 5th is at hand. I inclose in a vial, by this mail, a few of the live worms which I sent some time since. They have grown so much that I would hardly recognize them if I did not find them on the pea vines. They seem to do much damage, but are not yet very numerous. The first plant that I discovered was completely covered with the little worms like what I sent you first.—[F. H. HORSFORD, *July* 8, 1883.

[These were perfectly satisfactory, and were easily recognizable as the Zebra caterpillar (*Mamestra picta*, Harris), figured and described in Harris's Insects Injurious to Vegetation, in the second report on the Insects of Missouri, and in the report of the Entomologist of the Department for 1883. From its conspicuous appearance, and from the fact that the caterpillars are gregarious when young, it is easily destroyed by hand picking.]

LOCUSTS IN YUCATAN.

Referring to my dispatch No. 70, dated November 27, 1882, and to Department instructions No. 65 and 75, dated, respectively, January 3, 1883, and June 20, 1883, I have now the honor to report as follows:

The flights of locusts reported by me in my No. 70 increased in size and numbers, and invested the whole country, where they have bred with astonishing prolificacy. The situation of affairs here is exceedingly grave.

The whole country is now swarming with this insect in both the "'hopper" state and as the perfect insect. Nothing escapes their voracity. For a time hopes were entertained that the henequen plant* would be free, but now everything is being destroyed. Lamentable stories are brought in daily of the utter destruction of promising corn, bean, and henequen fields of vast extent. The peculiar conformation of the country renders any systematic and efficient warfare against them extremely difficult, if, indeed, practicable. Added to this is the natural "laisser aller" and indifference of the ordinary Mexican. Sporadic outbursts of energy are seen here and there, but very little is thus accomplished. The State legislature some time ago passed a decree calling on every male inhabitant of the State to give one day's work in each week towards killing locusts, or in lieu thereof 50 cents per week.

The decree is good, but, so far as I can learn, it has not yet been put into effect.

The results are already deplorable; cattle and horses are dying for want of food; the Indian who lives only on corn can no longer depend on the home crop, but must buy imported corn at the rate in city of Merida of $3.25 per "carga" of 94 pounds, say 3½ cents per pound wholesale, but by the time it reaches the Indian it costs him nearly 6 cents a pound. He can earn 25 cents a day. Part of this goes toward extinguishing his ever increasing debt to his employer, the remainder to provide for his great, hungry family.

In 1881 there were imported into this State 549,626 bushels of corn; this year three times this quantity will be needed, and unless this plague be abated, Yucatan will very shortly have no henequen fiber to send

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* *Agave sisalana.*

about in exchange for corn. Money is exceedingly tight; exchange at an extravagant figure, and in general the prospects of Yucatan are exceedingly gloomy.

I shall be pleased to furnish any details the Department may desire, or to answer any questions that may be put.—[LOUIS H. AYMÉ, *United States Consul, Merida, Yucatan, August* 25, 1883.

SUPPOSED IMPORTATION OF PHYLLOXERA.

The following correspondence having been the subject of several Associated Press dispatches last April, we print it in full:

TREASURY DEPARTMENT, *April* 17, 1883.

SIR: I transmit herewith a report from the collector of customs at New York, dated the 13th instant, in regard to the importation at that port of vine-cuttings, which it is suspected may be infected with phylloxera. The report of the examiner who made the examination is not conclusive on the question at issue, but even if it were I know of no law that authorizes this Department to prevent their delivery. Dr. Battershall, of the appraiser's office at New York, suggested that the clippings be submitted for examination to Professor Riley of your Department, and they are accordingly transmitted for such examination.

Please return the paper with such comments as you may deem proper.

Yours, very respectfully,

H. F. FRENCH,
Acting Secretary.

Hon. GEO. B. LORING,
Commissioner of Agriculture.

CUSTOM-HOUSE, NEW YORK,
Collector's Office, April 13, 1883.

SIR: I herewith transmit a communication from the United States consul at Funchal, inclosing invoice of vine-cuttings. The communication of the consul was referred to the appraisers immediately on receipt, and that officer's report thereon is herewith inclosed. I also forward the vine sample alluded to in the appraiser's report.

Being unable to find any provision of law authorizing the collector to seize or otherwise interfere with importations of this character, even though the vines are affected as surmised, I respectfully refer the matter to the Department, with the request that instructions be given as to any action to be taken by me in the premises.

Very respectfully,

W. H. ROBERTSON,
Collector.

Hon. CHAS. J. FOLGER,
Secretary of the Treasury.

PORT OF NEW YORK, APPRAISER'S OFFICE,
April 10, 1883.

SIR: Respectfully referring to the inclosed communication, directing that a microscopic examination be made of a sample of certain vine clippings recently imported from the island of Madeira, I have the honor to report as follows: I have submitted the above sample to a microscopic examination, and, while I have as yet been unable to detect certain positive indications of the presence of phylloxera, I am of the opinion, after comparing the clippings with others of known freedom from disease, that they present appearances which are at least suspicious. Considering the importance of this matter, I would respectfully suggest that the clippings under consideration be submitted for examination to Prof. C. V. Riley, who I believe is at present the entomologist of the United States Department of Agriculture, and who has devoted more attention to this special subject than any other American scientist.

An investigation would require experience of a peculiar nature, and would involve a more complete acquaintance with the physical appearance of the healthy and diseased vine than I can make claim to.

Respectfully,

J. B. BATTERSHALL.

The Hon. A. G. KETCHUM.

WASHINGTON, *April* 18, 1883.

SIR: In reply to the letter of the Assistant Secretary of the Treasury, with inclosures from the New York Custom-House, respecting an invoice of vine-cuttings from Madeira suspected of "phylloxera disease," I would submit the following:

The samples submitted, upon examination, furnish no sign whatever of Phylloxera, and it is extremely doubtful whether any trace of Phylloxera could be discovered upon any of the cuttings: 1st, because Phylloxera is not known to be destructive in Madeira; and, 2d, because it could only be found in winter egg, which, even in countries where Phylloxera abounds, is extremely rare. Hence the chances of the introduction of the pest upon these cuttings are so very remote as not to be worth considering. But, even if the cuttings came from a country badly infested with Phylloxera, the danger of the introduction of the pest upon them would be very slight, the reasons for which conclusion I have already discussed in the *American Naturalist* for March, 1881, and I beg leave to inclose a copy of said article, which gives in addition a succinct statement of the life habits of the insect.

Even were it possible to introduce the insect with these cuttings, no harm could result so long as they were sent to any part of the United States east of the Rocky Mountains, since the Phylloxera is indigenous here. On the same supposition that the cuttings were badly infested, prudence would dictate that they should not be sent to the Pacific coast, or those portions of it where the Phylloxera does not yet exist; but

for the reasons first given I do not hesitate to say that there can be no danger in sending them even there, and as it seems that there is no law to warrant their detention they may certainly be forwarded without fear of injury.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. GEO. B. LORING,
Commissioner of Agriculture.

FURTHER REPORTS ON THE GROWTH OF PYRETHRUM.

CALIFORNIA. San Bernardino, August 12, 1883.—JAMES S. BROOKS.

I have a few plants of pyrethrum now in flower, raised from seed that I sent East for last year, but as I do not know how to prepare the powder for the purpose of destroying insects I shall let the seed ripen and plant again next season, hoping that I will succeed better, as but very few plants came up.

CANADA. Dundas, Ont., June 22, 1882.—JOHN A. FISHER.

I have much pleasure in inclosing you three flowers raised by me from the pyrethrum seed which you so kindly sent me a little over a year ago. The plants that I have are in a perfect mass of bloom.

CANADA. Riverside, Toronto, September 9, 1883.—ALFRED H. MOORE.

A plant of the 1881 seedlings of pyrethrum rose bloomed last May (1883) so gloriously as to elicit a notice in the *Evening Telegram* of this city. Had in bloom, nearly at same time, twenty-seven heads, but no fecundated fruit. Are the flowers all entomophilous, and so abortive?

ILLINOIS. Champaign, July 12, 1882.—S. A. FORBES.

Concerning the pyrethrum seed sent me, I believe that I have not reported that I succeeded in raising a few plants last year, although most failed because of the severe drought. Those that grew survived the winter, blossomed this summer, and matured their seed about three weeks ago. This was *Pyrethrum roseum*. The seed of both species has come up sparingly this spring, injured this time by the extremely wet weather.

IOWA. Garrison, June 10, 1882.—JAMES H. DICKSON.

I received a package of pyrethrum seed (insect-powder plant) in the spring of 1881 from Professor Riley, and sowed seed in a shallow box and placed it in a hot-bed. The seed nearly all grew, and were transplanted to the garden the latter part of April. They grew fast and had a few blooms the latter part of September, but not enough to pay for the gathering. Before hard-freezing weather set in I gave the bed a

light covering of leaves, at the same time lifting a few plants and potting them, thinking if I lost those in the open ground that I would still have a start; but those in the open ground started with a vigorous growth, and to-day (the 10th of June) gathered a handful of blooms from a space 5 feet square. The blooms of those kept in the house are inferior to the others. The seed received of you this spring I gave the same treatment, with almost an entire failure; have several plants of each kind. We were well pleased with our former success, and expect to gather blooms enough this season to make powder, so that we can try its virtues on all kinds of insects that infest house plants.

KANSAS. Manhattan, May 2, 1883.—S. C. WELLS.

I gave away a part of the pyrethrum seed you sent me last spring, and planted the rest; some of them came up, but our dry winds or something else destroyed all but one plant. That one is now growing and looking well.

MASSACHUSETTS. Franklin, June 18, 1882.—RUTH H. SMITH.

The seeds of the *Pyrethrum roseum* received from you early in April, 1881, were planted according to direction. They came up, but did not seem to thrive well during the year. However, a few plants survived the severe hail-storm of July 4, and wintered well without any covering. They bloomed first about three weeks ago.

MICHIGAN. Burnside, October 22, 1883.—MICHAEL J. KIRWVEN.

According to your request I write to inform you of my success in raising the pyrethrum. I sowed the seed in a dark, sandy loam spot in my garden on the 23d of May. Of the *P. carneum* but one plant grew; *P. roseum*, five; *P. cinerariæfolium* from Austria, none; *P. cinerariæfolium* from California, about thirty-five plants grew. None of them have come to maturity. Will the *P. roseum* stand the winter without protection?

MISSISSIPPI. Oxford, April 28, 1883.—R. W. JONES.

The pyrethrum plants, which I mentioned in my report of January 11, 1883, are now blooming beautifully. I send you specimens of the blooms and leaves. They are (1) *Pyrethrum roseum*, (2) *Pyrethrum cinerariæfolium*. I think the only difficulty here in growing the plant is in getting it started. From my experience thus far I am led to the conclusion that in Mississippi the best time for sowing the seed is in October; seeds sown in the spring do not do so well, though I succeeded in raising some plants from seed sown in the spring. The hot, dry summer of this latitude is a severer trial to the plants when young than our winters are. In the spring, too, the rains are too heavy and too often repeated for the young plants to thrive. It is very interesting to watch insects that are attracted by the brightness of the colors of *P. roseum*, as they fly to the bloom and suddenly leave. I note that some

small insects, of which I send you specimens, and the bumblebee seem to use the blooms without hurt.

[The insect mentioned is *Cerotoma caminea*, Fabr.]

NEW YORK. Rochester, June 11, 1882.—M. ALDEN.

The seeds of *Pyrethrum roseum* sent to me fifteen months ago were divided into two parts and planted: 1st, in a gravelly loam—these did not live: 2d, in a flower bed partially shaded in summer, having a southern exposure, and composed of leaf-mold, one-half; well-rotted cow manure, one-fourth; clay, one-fourth. Liberal additions of waste coffee-grounds have been thrown on this bed from time to time. The pyrethrum planted there is in fine condition, and is now in bud; the plants are about 18 inches high. They did not flower last summer, and the roots were left out all winter, protected by three inches of leaves and manure.

PENNSYLVANIA. New Bloomfield, October 2, 1883.—E. W. CLAYPOLE.

In the spring of 1881 you sent me some seed of the Persian insect-plant, *P. roseum*. I sowed some of it and it came up well. It grew through the summer in a box and was left out through the winter. The roots being much exposed by the sides of the box were liable to be killed by frost. Yet it lived. I was away from home during the cold part of the winter, which came before Christmas, but at my return the plants were alive and continued so, at least some of them, until they began to grow in the spring, when, unfortunately, they were forgotten and exposed to a cold rain and sudden hard frost in March, which killed them in the growing state. In the spring of 1882 I sowed again some of the same seed, which I had kept over, and also some of the Dalmatian species, *P cinerariæfolium*. Both came up well. The seed leaves of the latter were less spatulate than those of the former, and the later leaves came more freely. Altogether, the latter is the more freely growing plant. They flourish well through the summer, and though the winter was a very cold one (in Pennsylvania), yet with very little shelter (such as that of an open shed or an unwarmed room) they survived it, and in the spring began to grow very early. May add that the Dalmatian species was evergreen, retaining its leaves all the winter. The other was not. In the spring I planted them in an open border, where they grew well and flowered, especially the Persian plant, the flowers being crimson, magenta, and white. The other species did not bloom as freely. I do not know how they will bear the winter in the ground, but the probability is in their favor. Judging from appearances the seed of neither species was matured.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF ENTOMOLOGY.
BULLETIN No. 5.

DESCRIPTIONS OF NORTH AMERICAN

CHALCIDIDÆ

FROM THE COLLECTIONS OF THE U. S. DEPARTMENT OF AGRICULTURE AND OF DR. C. V. RILEY,

WITH

BIOLOGICAL NOTES.

[FIRST PAPER].

TOGETHER WITH A LIST OF THE DESCRIBED NORTH AMERICAN SPECIES OF THE FAMILY.

BY

L. O. HOWARD, M. Sc.,
ASSISTANT, BUREAU OF ENTOMOLOGY.

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9255—5 ENT

DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., January 9, 1885.

SIR: One of the obstacles which the economic entomologist encounters in this country is the impossibility of properly referring by name to the majority of the insect enemies and parasites of very many of the most prominent injurious species. This difficulty has been greatly felt in the work of this Bureau, and some endeavor has been made to have certain families, like the Tachinidæ and Syrphidæ in Diptera, worked up. In the smaller Hymenoptera a very large amount of undescribed material has been reared, and as Mr. Howard has made a specialty of their study, I have desired that he devote whatever time he can well spare from his other duties, to working this material up. The paper herewith presented is the first of a series of descriptive papers which are intended to overcome the difficulty mentioned, and which, being technical and intended for circulation among entomologists, need only be printed in limited edition.

Respectfully,

C. V. RILEY,
Entomologist.

Dr. GEORGE B. LORING,
Commissioner of Agriculture.

FAMILY CHALCIDIDÆ.

Subfamily LEUCOSPINÆ.

Genus LEUCOSPIS Fabr.

In this genus the fore wings are folded as with the true wasps, the hind femora are greatly thickened, the tibiæ are broadened at their extremities, and the ovipositor of the female is curled up over the dorsum of the abdomen, usually reaching to the thorax.

1. Leucospis affinis Say.

This species is represented by two ♂ specimens taken in Northern Virginia in September. It is a common species, found from Canada to Texas, and is supposed to live in the nests of wild bees. [C. V. R. Coll.]

Subfamily CHALCIDINÆ.

The three genera which we shall consider in this subfamily may be separated as follows:

A. Abdomen petiolated .... SPILOCHALCIS.
B. Abdomen sessile.
  a. Posterior tibia produced to a single spine at tip. Antennæ inserted at the middle of the face .... CHALCIS.
  b. Posterior tibia two-spined. Antennæ inserted below the middle of the face. HALTICHELLA.

NOTE.—In this first paper on the Chalcididæ in the collection of the United States Department of Agriculture and that of Dr. C. V. Riley, which has been constantly used in the work of the Department, I have taken up the six subfamilies *Leucospinæ*, *Chalcidinæ*, *Encyrtinæ*, *Aphelininæ*, *Elachistinæ*, and *Elasminæ*. In numbers these subfamilies are not largely represented, but the material is mainly undescribed and is rendered valuable by the accompanying notes on habits and dates of issuance, which are connected with numbers in the collections. The hosts not specifically referred to are undetermined by Dr. Riley, and are, so far as known, undescribed.

L. O. HOWARD.

JANUARY 1, 1885.

Genus SPILOCHALCIS Thomson.

Head triangular; antennæ separated at base by a triangular notched elevation; thorax usually marked with yellow; metathorax rugose; fore wings with long marginal and postmarginal veins; abdomen, subglobose; petiole, moderately long, cylindrical; posterior margin of the femora densely serrate, except in *missouriensis*, which has four widely separated teeth; posterior tibiæ produced into a spine, and *middle tibiæ with a distinct spine.*

2. (1) Spilochalcis mariæ (Riley).

This common parasite has been reared from the following insects:

Antheræa polyphemus.—24 ♂, 23 ♀ specimens were bred from a cocoon of this species by V. T. Chambers, at New Orleans, La., in 1869. The collection also contains specimens bred from the cocoons of this moth by Dr. Hoffmeister, at Fort Madison, Iowa. [C. V. R. Coll.]

Samia cecropia.—Specimens bred by Mrs. Treat, at Vineland, N. J. [C. V. R. Coll.]

Callosamia promethea.—Same as preceding. [C. V. R. Coll.]

Attacus cynthia.—From a lot of 202 cocoons received from S. Lowell Elliot, New York City, were bred, in May, 1881, 113 ♀'s, 36 ♂'s. The former varied from 4^{mm} to 8^{mm} in length, and the latter from 3.5^{mm} to 6^{mm}. [Dept. Agr. Coll.]

Specimens bred from this species were received from A. H. Mundt, Fairbury, Ill. [C. V. R. Coll.]

Thyridopteryx ephemeræformis.—A specimen was bred from a bag of this insect, May 11, 1869, at Saint Louis. [C. V. R. Coll.]

3. (2) Spilochalcis missouriensis n. sp.

Female.—Length, 5^{mm}. Posterior femora with *four* widely separated teeth. Color, bright scarlet, marked with black as follows: Flagellum of antennæ, with the exception of club at tip; clypeus and occiput; a large circular spot on the mesonotum; a transverse band on the metanotum; an irregular spot on each side near tip of abdomen; a large spot on each side of the thorax just below tegulæ; a dorsal spot near the tip of the posterior coxæ; a minute circular spot on the dorsum of each hind femur, and two large round spots latero-ventrally, one in the middle and one at tip; spines of femur; a spot at the base of the hind tibiæ. The wings are slightly dusky, with a pronounced fuscous spot around club of stigmal vein; stigmal club securiform, entire; all wing veins brown.

Described from 1 captured ♀ (♂ unknown), Saint Louis, Mo., July. [C. V. R. Coll.]

Seems to come nearer to *Smicra lanieri* (Guer.), Cuba, than to any other described species.

4. (3) Spilochalcis virens, n. sp.

Male.—Length, 8^{mm}; expanse, 18^{mm}; greatest width of fore wing, 3.2^{mm}. Resembles somewhat *Sm. mariæ* (Riley). Pedicel short and slender; hind femora, 12-15 toothed. Colors, black and yellow; facial grooves, vertex, and occiput black; remainder of head yellow; scape of antennæ yellow, black above near tip; flagellum, black; first three joints brownish below; pronotum yellow, with a black spot anteriorly and one at each dorsal lateral angle; mesoscutum black, with four narrow longitudinal stripes;

axillæ yellow, black at tip; mesoscutellum yellow, with a broad central longitudinal black band; metanotum yellow, with a transverse black band and with two longitudinal lateral bands; pedicel black with a large yellow spot above; abdomen yellow, the joints above edged with black; front and middle legs entirely yellow, except that the middle coxæ and trochanters are tinged with brown at base; hind coxæ black, with a forked yellow stripe outside and a broad yellow band inside; hind femora yellow, inner disk edged with black, outer face with a short oblique tapering black stripe; hind tibiæ and tarsi yellow, the former with a brown shade on the edge toward the femora; wings slightly cloudy, veins yellow; stigmal club entire.

Described from 1 ♂ collected at Fort Madison, Iowa, by Dr. A. W. Hoffmeister. [C. V. R. Coll.]

5. (4) **Spilochalcis odontotæ**, n. sp.

Male.—Length of body, 2.4^{mm}; expanse of wings, 5.4^{mm}. General color light lemon-yellow; flagellum of antennæ with a strong ferruginous tinge; occiput, black; pronotum with a small black spot on either side; mesocutum with a median faintly-defined black spot; mesoscutellum with a similar well-defined spot; borders of all mesonotal sutures black, the posterior and outer borders of the scapulæ more widely edged with black than the other parts; metanotum and metasternum with blackish patches; pedicel nearly white, semi-transparent; abdomen, honey-yellow, each segment edged with black, second segment bright lemon-yellow; legs nearly white; hind coxæ with a dusky spot at internal base; teeth of hind femora black, and both hind femora and tibiæ faintly mottled with ferruginous. Wings clear; veins nearly black; stigmal club slightly notched.

Described from 1 ♂ specimen, bred July 31, 1884, from the pupa of *Odontota scutellaris*, mining leaves of *Robinia pseudacacia* at Washington, D. C. [C. V. R. Coll.]

6. (5) **Spilochalcis delira**, (Cress).

This species was described by Cresson from a male specimen collected in Texas by Belfrage. Two females studied in this connection, one taken by Mr. Schwarz in Florida (Haw Creek), in July, 1883 [Dept. Agr. Coll.], and the other collected on cotton by Mr. Patton, at Selma, Ala., October, 1881 [C. V. R. Coll.], seem without much doubt referable to this species, and I so place them pending an actual comparison of specimens.

7. (6) **Spilochalcis albifrons** (Walsh).

This is the species described by Walsh (Trans. Ill. State Agr. Soc. iv., 1861) as a secondary parasite on his *Pezomachus minimus*, bred from the army worm (*Leucania unipuncta*, Haw.). It was originally described as a *Chalcis*, but evidently belongs in *Spilochalcis*. It is represented by one poor specimen. [C. V. R. Coll.]

Genus Chalcis Fabr.

Head short, triangular; antennæ inserted a little below the middle of the face; their bases but slightly separated, and the scape entirely contained within the antennal groove; postmarginal vein of the fore wings shorter than the marginal; abdomen almost sessile, oblong, subtriangular; anterior femora subfusiform, posterior ovate, with a crenate lower margin; middle tibiæ each with a spur at tip; posterior tibiæ prolonged at tip into a spur.

8. (1) **Chalcis ovata** Say.

A number of specimens of this species occur in the collections. They vary greatly in size (between 6^{mm} and 3^{mm} in length), and were bred from the following insects:

Thyridopteryx ephemeræformis.—Specimens were bred October 14, 1882, from bags of this species collected at Washington, D. C. [Dept. Agr. Coll.]

Apatura clyton.—Specimens were bred, September 17, 1878, from the pupæ of this species collected at Columbia, S. C. [C. V. R. Coll.]

Aletia xylina.—Many specimens bred from pupæ of this species, from August 4 to September 10, 1879, and during subsequent autumns, received from various southern States, especially Alabama and Texas. [C. V. R. and Dept. Agr. Coll.]

Desmia maculalis.—Missouri (no date). [C. V. R. Coll.]

Cacœcia rosaceana (?).—One very small specimen bred June 12, 1873. [C. V. R. Coll.]

Gelechia gallæ-solidaginis.—Missouri (no date); a very small specimen. [C. V. R. Coll.]

Botis alnialis Riley MSS. District of Columbia, October 8, 1883. [Dept. Agr. Coll.]

9 (2) **Chalcis robusta** Cresson.

This species was described by Mr. Cresson (Proc. Ent. Soc. Phila., iv, 1865, p. 101) from four Cuban specimens. There is one specimen in Professor Riley's collection which agrees perfectly with the description, and which was bred by Mr. Hubbard, September 14 or 15, 1881, at Crescent City, Fla., from a cocoon of *Lagoa opercularis.* Mr. Hubbard, also, in June or July, 1882, bred another specimen of this insect from a chrysalis of *Papilio cresphontes*, also at Crescent City. The chalcid issued from a large circular hole cut through the thorax of the pupa. [Dept. Agr. Coll.]

10. (3) **Chalcis columbiana**, n. sp.

Female.—Length, 5^{mm}. Head and dorsum of thorax black, with whitish hairs and large close punctures; scape of antennæ ferruginous; tegulæ, yellowish-white; abdomen, ferruginous, with the last joint black, and the dorsum of the last five joints also black; front coxæ black, middle and hind ferruginous; middle femora with a black central spot; hind femora ferruginous, with a yellow spot at tip; tibiæ with a yellow spot at either end. Wings hyaline, veins dark brown.

Described from 1 ♀ collected in District of Columbia July 10, 1880. [C. V. R. Coll.]

Comes near description of *C. coloradensis* Cress., but may be distinguished by its ferruginous hind coxæ and basal abdominal joints.

11. (4) **Chalcis tachinæ**, n. sp.

Female.—Length, 4.4^{mm}; expanse, 7.6^{mm}. This species comes close to *C. coloradensis* Cress. General color black; tegulæ yellow; all legs ferruginous, except coxæ; middle femora and tibiæ with a dusky band in center; teeth of hind femora black; hind femora with a yellowish spot at apex; hind tibiæ with a blackish stripe ventrally.

Described from 1 ♀ specimen. This specimen was bred, December 29, 1883, from the puparium of a Tachinid, the larva of which was found with the eggs of *Caloptenus atlanis* Riley, at Boscawen, N. H., October 7, 1883. The Tachinid larva showed no signs of being infested, and transformed to an apparently healthy pupa. [C. V. R. Coll.]

Genus HALTICHELLA Spinola.

Head triangular; eyes large. Antennæ inserted contiguously, near the mouth; scape long, reaching to the ocelli. Anterior wings with a short marginal vein, very short stigmal and still shorter post-marginal. Abdomen ovate, second segment somewhat flattened above. Posterior femora smooth below, or obtusely bidentate. Posterior tibiæ with two spurs, middle with one.

12. (1) **Haltichella americana**, n. sp.

Female.—Length, 4^{mm}. Head and thorax densely and coarsely punctured, more closely on occiput. Color black, with whitish pile. Front coxæ, and femora black, tibiæ ferruginous at either end, tarsi ferruginous; middle legs the same; hind legs entirely black, tarsi ferruginous. Wings very slightly dusky under the stigma.

Described from 2 ♀'s, both collected at Washington, D. C. [C. V. R. Coll.]

Approaches very closely *H. armata* (Panz.) of Europe, but differs in the completely black antennæ and the nearly clear wings.

Sub family ENCYRTINÆ.

The eight genera of this subfamily, which are represented in the collections, may be separated as follows, the females alone being considered:

A. Scutellum with a tuft of stiff hairs at tip............................CHILONEURUS.
B. Scutellum with no such tuft.
  a. Head with very deep, large, and regular round impressions....BOTHRIOTHORAX.
  b. Head with no such sculpture.
    a. Head thickly and finely punctate, antennal club often obliquely truncate. COPIDOSOMA.
    b. Head nearly smooth, antennal club always strongly obliquely truncate. HOMALOTYLUS.
    c. Antennal club not obliquely truncate.
      aa. Mesonotum lusterless..APHYCUS.
      bb. Mesonotum shining with a metallic luster.
        aa. Antennæ extremely long and thin; no marginal vein........PSILOPHRYS.
        bb. Antennæ very long and thin; marginal vein longer than stigma. LEPTOMASTIX.
        cc. Antennæ not specially long ....ENCYRTUS.

In the Annual Report for 1880 I described twelve species of this subfamily, all of which were parasitic upon bark-lice. I here describe twenty-three additional species, but of these only eight are bark-louse parasites, three are parasitic upon Psyllidæ, five upon Lepidopterous larvæ, one upon a Coleopterous larva, and two upon Dipterous larvæ, while the hosts of four are unknown. Of these four the strong probabilities are that one is parasitic upon some Dipterous larva, one upon a Lepidopterous, and the other two upon bark-lice.

Genus COPIDOSOMA Ratzeburg.

Female.—The antennæ arise near the border of the mouth; the scape is long and slender; the six-jointed funicle long and slender, or short and comparatively thicker; the club is either long, delicately bent and somewhat rounded at tip, or it is thicker and markedly obliquely truncate. This truncation is produced by the drying of a strip of more delicate membrane upon one side of the club. Front and vertex closely punctured, without larger deep punctures. The mesoscutum and often the scutellum have with most species a sculpture which was called by Ratzeburg "schuppig" (scaley), and also a thicker punctuation with round or aciculate punctures. The marginal vein is either lacking, or it is a little shorter than the stigmal. The wings are hyaline. The ovipositor is very long, but may also be entirely hidden.

Male.—The male resembles the female in the form of the body, in the punctuation, and also in the relative proportion of the wing veins, differing to a marked degree only in the antennæ. These are given off near the border of the mouth as with the female; the scape is long and slender, the pedicel shorter than the first funicle joint; the funicle is rather thickly covered with short hairs (the hairs shorter than the joints), with the joints separated above more than below; the club is about as thick as the funicle. The base of the scutellum has a more or less delicate longitudinal carina, but no furrow.

13. (1) Copidosoma gelechiæ n. sp.

Female.—Length, 1.5^{mm}; expanse, 3.5^{mm}; greatest width of fore wing, 0.65^{mm}; antennal club of the obliquely truncate type, as long as the five preceding funicle joints together; pedicel of the same length as the first funicle joint; funicle joints gradually decreasing in length from 1 to 6. Punctures of head nearly round, of mesoscutum lengthened somewhat longitudinally, of the axillæ transversely aciculate towards tip, broader near base, of the scutellum longitudinally aciculate, especially narrow down the median line; ovipositor extruding but slightly; marginal vein wanting. Color: Head and pronotum, black, with purplish reflections; antennæ, dark brown, nearly black throughout, end of pedicel yellowish; mesoscutum, bright golden green; axillæ, somewhat more subdued; mesoscutellum very dark brownish-green, tegulæ of the same color; abdomen smooth and shining with a greenish luster; all coxæ dark green; front and middle legs entirely honey-yellow; hind femora dark green, yellow at tip; hind tibiæ yellow, with a dark band around proximal third; tarsi yellow.

Male.—Length, 1.6^{mm}; expanse, 3.9^{mm}; greatest width of fore wing, 0.79^{mm}. Antennal club but slightly longer than sixth funicle joint; pedicel nearly as thick as long; first funicle joint nearly three times as long as pedicel. Punctuation like that of ♀. Color: Head, pronotum, and mesoscutum all bright golden-green; axillæ and mesoscutellum, a shade less brilliant; all legs nearly black throughout, with a greenish luster, and with the knees yellowish; middle tibial spur and first tarsal joint also yellow; remainder of middle tarsi and all joints of fore and hind tarsi blackish.

Described from 4 ♀'s and 4 ♂'s bred from the larvæ of *Gelechia gallæ-solidaginis* collected in District of Columbia. The parasites issued October 19.

Variety a.—What may be called a variety of this species was bred in great numbers by Mrs. Mary Treat from *G. gallæ-solidaginis*, August 8, in New Hampshire. The female of this variety lacks the brownish

band on the hind tibiæ, and the male has wider yellow bands at all the knees, and the tarsi are lighter in color.

Variety b.—In this variety the hind femora become entirely honey-yellow. Many specimens occur among those bred from *G. gallæ-solidaginis* in Missouri; and an intermediate form, in which the hind femora have a blackish shade, also occurs among the same lot of specimens.

It was this variety which was popularly described by Professor Riley in the first Missouri Entomological Report (p. 176) as "the Inflating Chalcis"; giving an account of its habits, in which it does not differ from other members of the genus, except that, inasmuch as its host is a gall-inhabiter, it has to escape from the gall as well as from the inflated skin. All the individuals, according to the report just mentioned, "escape through a single minute hole which must be made by one of their number"; but it has also been observed that where the host has already prepared the opening for its own future exit, before succumbing to the attacks of the parasites, the latter make use of this opening for their egress. [C. V. R. and Dept. Agr. Coll.]

14. (2) Copidosoma vagum, n. sp.

Female.—Length, 1.4^{mm}; expanse, 2.8^{mm}; greatest width of fore wing, 0.46^{mm}. Club of antennæ delicately curved, not obliquely truncate, as long as the two preceding funicle joints together. Punctures of head round, of mesoscutum and axillæ nearly round, somewhat polyhedral; of scutellum longitudinally aciculate; abdomen slightly transversely shagreened at base; ovipositor one-third as long as abdomen. Color: Antennæ black, scape with metallic luster; head and pronotum dark and somewhat purplish; mesoscutum bright greenish; scutellum coppery; abdomen shining greenish-black; all coxæ and femora shining black; front and middle femora, yellowish at tip; all tibiæ yellow, middle and hind with a brown ring near base, and fore with a brownish shade above; front and hind tarsi dusky; middle tarsi and tibial spur light yellow.

Male.—Length and proportions about the same as with ♀, except that the wings are somewhat longer and stronger. Club twice as long as sixth funicle joint, first funicle joint twice as long as pedicel. Punctation as in ♀; abdomen more strongly shagreened; mesoscutellum with a faint median longitudinal carina; colors as with the ♀, except that the hind tibiæ are almost entirely black, and the front tibiæ entirely brown; hind tarsi white, except last two joints.

Described from four ♀'s and many ♂'s bred from the larvæ of *Gelechia pseudacaciella* Chambers, in Missouri in May. [C. V. R. Coll.]

15. (3) Copidosoma celænæ, n. sp.

Female.—Length, 0.93^{mm}; expanse, 2.28^{mm}; greatest width of fore wing, 0.37^{mm}. Antennæ, rather short; club of the obliquely truncate type; pedicel three times as long as first funicle joint, which is thicker than long; funicle joints increasing slightly in length, and in about the same ratio in thickness; club as long as the five preceding funicle joints together. Head and mesoscutum with roundish polyhedral impressions, those on the head becoming somewhat elongate transversely towards occiput, and those on scutum longitudinally towards scutellum; axillæ with the same, becoming transversely aciculate towards tip; punctures of mesoscutellum roundish at immediate base, but longitudinally aciculate elsewhere. Color: Head, mesoscutel, axillæ and tegulæ dark with a coppery luster; mesoscutum dark golden-green; anten-

næ black, abdomen dark with a greenish luster, transversely shagreened above; all coxæ and femora black; front and hind tibiæ dark brown, whitish at base; middle tibiæ light brown, whitish at both base and tip; front and hind tarsi yellow brown; middle tarsi whitish.

Described from many ♀'s, no ♂'s; bred, May 16, from the larva of *Celæna renigera*, collected at Saint Louis, Mo. The parasited larva did not present the usual honeycombed appearance, on account of its large size and tough brown skin. The parasites, too, are very small, and the minute punctures made in exit are almost imperceptible. On breaking the larva open, however, the honeycomb structure is at once apparent. [C. V. R. Coll.]

16. (4) **Copidosoma intermedium.** n. sp.

Female.—Length, 1.25^{mm}; expanse, 3.2^{mm}; greatest width of fore wing, 0.57^{mm}. Differs from *C. gelechiæ* in the following particulars: Punctures of mesoscutum only slightly elongated longitudinally behind; punctures of mesoscutel subaciculate longitudinally, but not so sharp as in *gelechiæ;* of axillæ, nearly round. Antennæ, black; front legs dark brown throughout; middle legs with dark brown femora, a light-brown shade near base of tibia; most of ia, tibial spur, and tarsi light yellow; hind legs with greenish femora, dark brown tibiæ yellow at tip, and yellow tarsi.

Male.—Dimensions same as in female, except that the fore wing measures 0.6^{mm} in width. Punctures of vertex with a transversely elongate tendency; of mesoscutel even broader than those of ♀, narrower in center near base than elsewhere. Flagellum of antennæ strongly flattened; joint 1 of funicle, three times as long as pedicel, and considerably wider. In color differs from ♀ as follows: Antennæ, brown; scape darker than flagellum; head, pronotum, mesoscutellum, and axillæ with a strong bluish-green luster; front and middle femora and tibiæ dark brown, with yellowish tips; hind femora and tibiæ nearly black, with greenish luster, yellow only at joints; front and hind tarsi brown, middle tarsi yellow.

Described from 2 ♀'s and 25 ♂'s bred, October 11, from the larvæ of ***Gelechia gallæ-asterella*** **Kellicott, in galls collected at Vineland, N. J., by Mrs. Mary Treat; also bred in August from galls of the same insect collected around Saint Louis. [C. V. R. Coll.]**

Genus Encyrtus Dalman.

Female.—Antennæ 11-jointed, inserted not far from the border of the mouth, moderately thick, and, with the exception of the scape, very seldom compressed; the scape is often strongly broadened; the club is rounded, or with a slight oblique truncation at tip. The facial impression is rather large and often quite deep. The mesonotum is transversely arched, shagreened, and more or less lustrous; the scutellum shows a different sculpture. The wings are always developed and ciliated; the marginal vein is present, seldom very short; the stigmal is moderately long. The ovipositor is not as long as half the abdomen.

Male.—The flagellar joints are slightly or not at all compressed, and covered equally (not in half whorls) with hairs.

17. (1) **Encyrtus sublestus,** n. sp.

Male.—Length, 1.28^{mm}; wing expanse, 2.66^{mm}; greatest width of fore wing, 0.51^{mm}. Scape short, four times as long as thick; pedicel, at distal end, as thick as long; first flagellar joint, two and one-fourth times as long as pedicel; remaining flagellar

oints subequal, the third being the shortest; the club is nearly as long as the two preceding joints together; all joints, except scape and pedicel, furnished with long *non-whorled* hairs. Head and mesonotum very delicately but distinctly punctured. Color: Head and thorax metallic blue-black, abdomen shiny black; all coxæ metallic blue-black; all femora brown, light at tips; all tibiæ dusky, light at tips, the hind tibiæ darker than the others; all tarsi pure white with dark claws. The stigmal vein is longer than the marginal, which is very short and thick.

Described from 1 ♂ specimen (♀ unknown) bred, April 6, 1882, from *Lecanium* sp. on *Pinus australis*, collected at Archer, Fla. [C. V. R. Coll.]

18. (2) **Encyrtus ensifer**, n. sp.

Male.—Length, 0.66^{mm}; wing expanse, 1.75^{mm}; greatest breadth of fore wing, 0.36^{mm}. Antennæ long and furnished with long hairs arranged in two irregular whorls; pedicel and flagellar joints subequal in length and about 1.5 times as long as broad; the flagellar joints are deeply incised dorsally, giving each a moderately strong, rounded, dorsal prominence; the club is somewhat longer than the two preceding flagellar joints. Head and mesonotum very delicately and finely punctured. Color: Head, thorax, and abdomen shiny dark-brown, nearly black; antennæ light brownish-yellow; all legs dusky, light at joints; wing-veins dusky, marginal vein darkest. Stigmal vein longer than marginal, uncus consisting of four cells. [The penis, as shown in one specimen, is somewhat hastate and not bifid as with *Eupelmus* and other chalcids.]

Female.—Length and proportions much the same as those of the ♂. Antennæ somewhat compressed; scape not widened; pedicel twice as long as wide and somewhat longer than first flagellar joint; all flagellar joints subequal in length and width and flattened cylindrical in form; club large, oval, compressed laterally, as long as three preceding flagellar joints. Sheath of ovipositor more than half the length of abdomen. In every specimen examined the ovipositor was not contained in its sheath, but stretched out from its insertion in the first abdominal joint in a sword-like curve as long as the whole body. General color as with ♂; base of antennal scape dusky, tip yellow, pedicel dusky throughout, flagellum light yellow-brown; legs slightly dusky, except at ends of joints; ovipositor bright yellow, sheath dark brown.

Described from 3 ♂, 4 ♀ specimens, bred June 1 and 5, 1882, from *Aspidiotus corticalis* Riley MSS., on peach, collected at Crescent City, Fla., by H. G. Hubbard. [Dept. Agr. and C. V. R. Coll.]

19. (3) **Encyrtus fuscicornis**, n. sp.

Female—Length, 1.93^{mm}; wing expanse, 4.6^{mm}; greatest width of fore wing, 0.69^{mm}. Punctuation of mesonotum very delicate. Antennal scape slender, not widened. marginal vein present, but shorter than stigmal. General color dark honey-yellow; antennal scape dark yellow, pedicel and first three funicle joints fuscous, last three funicle joints light yellow, club black and compressed; scutellum dusky and and with an irridescent tinge; tegulæ dusky at tips; metanotum black; superior surface of abdomen black, inferior surface dusky, all legs uniformly yellow. Wings fuscous, somewhat clear at base, and with two transverse hyaline streaks, the broader of the two, just at tip of stigma, with its proximal border concave and its distal border straight, and the narrower one at outer third of wing with its two borders parallel.

Described from 1 ♀ specimen collected at Odenton, Md., June, 1882. [C. V. R. Coll.]

20. (4) **Encyrtus puncticeps**, n. sp.

Female.—Length, 2.2^{mm}; expanse of wings 4.42^{mm}; greatest width of fore wing, 0.69^{mm}. Scape, slender, not widened; pedicel, stout, conical; funicle joints, except first and second, wider than long, and the exceptions are but slightly longer in proportion to their width; club flattened, pointed at tip and very obliquely truncate from near base to tip. Head and face very thickly and finely punctulate; ocelli in a somewhat acute-angled triangle; mesonotum thickly and finely punctate. Color: Head dark reddish-brown, scape and pedicel the same, funicle blackish, club black; margin of eyes black; pronotum dusky; mesonotum dark honey-yellow, with the scuto-scutellar furrow and the tips of scapulæ black; tegulæ light yellow, black at tips; metanotum and abdomen, black; front, middle, and hind coxæ and femora and front and middle tibiæ, honey-yellow; hind tibiæ and tarsi metallic blue-black; middle tarsi, except basal half of first joint, black; front tarsi dusky. Wings hyaline except a subcircular brown patch just beneath stigma; marginal vein lacking, postmarginal short.

Described from 2 ♀ specimens collected at Arlington, Va., September, 1881. [C. V. R. Coll.]

21. (5) **Encyrtus bucculatricis** Howard.

This species, which was described and figured in Lintner's first report as State entomologist of New York, was first bred by Professor Riley, in the spring of 1874, from the cocoons of *Bucculatrix pomifoliella* (collected at Allenton, Mo.), together with *Cirrospilus flavicinctus* Riley, a small Braconid and a minute Tetrastichid, the latter being probably a secondary parasite. The Encyrtus was by far the most numerous of these parasites, and was continually issuing from the latter part of March until the first week in July.

In July, 1884, it was bred from the cocoons of a *Bucculatrix* on oak on the Department grounds at Washington. From one to three of the parasites issued from a single cocoon. The species was originally described from the ♀ only, but among these last bred was one ♂. The male is somewhat smaller than the female, the tibiæ are dark brown in color, and the antennæ light brown. The joints of the flagellum are well separated and furnished with well-marked whorls of hair. [C. V. R. and Dept. Agr. Coll.]

22. (6) **Encyrtus trioziphagus**, n. sp.

Female.—Length, 1.3^{mm}; wing expanse, 2.9^{mm}; greatest width of fore wing, 0.51^{mm}. Antennal scape stout, short, not reaching to top of the eyes, with no foliation below; pedicel short, conical, as thick as long and not exceeding in length the first funicle joint; joints of funicle hard to distinguish, somewhat flattened and subequal in length, sixth as broad as long; club subfusiform, as long as three preceding funicle joints together. Antennal grooves deep; two slight malar impressions; clypeus and vertex covered with fine punctures, lower face smooth, eyes wide apart; ocelli form a very obtuse angled triangle. Mesonotum delicately shagreened, with slight, sparse punctures, each giving rise to a short, delicate hair; no marked difference between scutum and scutellum in punctuation; axillæ just meet at tips. Wings perfectly clear; marginal vein wanting; stigmal one-third longer than postmarginal. Abdomen nearly circular, sunken in center. Color: Flagellum of antennæ brown; scape and pedicel black, with a greenish luster; lower part of face with a brilliant purplish-blue luster; clypeus and vertex dark coppery-brown; pronotum, coppery;

mesonotum bright shining green, the scutum somewhat more brilliant than the scutellum; metanotum and abdomen shining black, with a dark green luster; all coxæ and femora dark green, honey-yellow at tips; front tibiæ honey-yellow, greenish at base; middle tibiæ entirely honey-yellow, sometimes with a slight green spot near base; hind tibiæ green, honey-yellow at either end; front and hind tarsi brownish; middle tarsi yellow.

Male.—Length, 1^{mm}; wing expanse, 2.5^{mm}; greatest width of fore wing, 0.5^{mm}. Differs from ♀ chiefly in the antennæ. The flagellum is much flattened; scape still shorter than in ♀; pedicel very short and insignificant; joint 1 of the funicle twice as long as wide, and three times as long as pedicel; joints 2, 3, and 4 are fang-shaped dorsally; joint 3 more acute than 2 or 4; joints 5 and 6 resemble joint 1 in size and proportions; club short and suboval. Abdomen short and subcordate in form.

Described from 4 ♀'s and 2 ♂'s bred, November 7, 1881, from the galls of the Psyllid *Trioza diospyri* (Ashmead), on the Persimmon (*Diospyros virginiana*) on the Department grounds at Washington.

This species is markedly different from *Encyrtus triozæ* André, bred by M. Ed. André from *Trioza centranthi* Vallot, and described in Ann. Soc. Ent. France, 1878, p. 84; but belongs to the same group of the genus *Encyrtus* as *E. strobili* (L.), to which it is quite closely related. *E. strobili*, however, preys upon certain gall-making Cecidomyids, as *Cec. rosaria* and *C. salicina*.

A single Encyrtus issued from a single Trioza in every case, making its way through the dorsum of the abdomen of its host. [Dept. Agr. and C. V. R. Coll.]

23. (7) **Encyrtus solus,** n. sp.

This species also belongs to the group of *E. strobili* (L.), and does not differ structurally from *E. trioziphagus* to a material extent. In size and coloration it does differ quite markedly.

Female.—Length, 2^{mm}; wing expanse, 4.2^{mm}; greatest width of fore wing, 0.7^{mm}. Mesonotum somewhat more deeply shagreened than with *trioziphagus*. Color: The basal portion of each antennal joint brown, distal portion honey-yellow; face black, with a faint bluish tinge; mesonotum black, faintly greenish; abdomen shiny black. All legs entirely yellow, except hind coxæ, which are black, with a greenish luster.

Described from 1 ♀ specimen bred, March 14, 1879, from the gall of *Trioza magnoliæ* (Ashmead), on *Persea carolinense* (Red Bay), collected at Gainesville, Fla. Its habits appear to be the same as those of the preceding species. [C. V. R. Coll.]

24. (8) **Encyrtus pachypsyllæ,** n. sp.

This species is closely related to *E. trioziphagus*. The minute spines at the distal end of the posterior tibia, opposite the tibial spur, are longer and more curved than with *trioziphagus*. The coloration differs in that with *pachypsyllæ* the tibiæ and tarsi are all light honey-yellow, and the flagellum of the ♂ antenna is light brown. The ♂ antenna also differs from that of *trioziphagus* in that joints 1, 2, and 3 of the funicle are fang-shaped instead of 2, 3, and 4. The dimensions on the average are the same in both species, although *pachypsyllæ* is quite variable in the ♀.

Described from many ♂ and ♀ specimens bred, between May 5 and 10, 1884, from galls of *Pachypsylla celtidis-gemma* Riley, collected in Southern Maryland. [Dept. Agr. and C. V. R. Coll.]

25. (9) **Encyrtus cecidomyiæ**, n. sp.

Female.—Length, 1.8^{mm}; expanse 3.84^{mm}; greatest width of fore wing, 0.72^{mm}. Comes closer, perhaps, to the European *E. notodontæ* of Mayr than to any other species. The scape is nearly cylindrical; pedicel somewhat bulbous; funicle joints very gradually decreasing in length and increasing in width from joint 1, which is one and one-half times as long as thick, to 6, which is nearly as thick as long; the club is oval, much compressed, and as long as the three preceding funicle joints together. Head and notum very delicately and uniformly punctured, the punctation of the mesoscutum and scutellum identical. General color metallic-green, flagellum of the antennæ black, all tarsi brown, femero-tibial articulation of front and middle legs, and distal tip of middle tibiæ and accompanying spur honey-yellow. Marginal vein wanting, stigmal a trifle longer than postmarginal.

Male.—Dimensions, punctation and coloration nearly the same as with ♀. Differs in the antennæ, the scape of which is very short and slightly emarginate beneath; pedicel short, less than half the length of first funicle joint; funicle joints subequal in length, subovoid in shape, well separated, and clothed with moderately long hairs; club oval, as long as last two funicle joints together; club and funicle honey-yellow, scape and pedicel black.

Described from many ♂ and ♀ specimens bred, April 12, 1884, from the galls of *Cecidomyia salicis-siliqua* Walsh, collected in Northern Virginia. [Dept. Agr. and C. V. R. Coll.]

Genus CHILONEURUS Westwood.

Female.—Antennæ given off near the border of the mouth, 11-jointed; pedicel longer than the succeeding joint; the flagellum is cylindrical or somewhat flattened; club spindle-shaped or compressed. Vertex narrow; head and face not coarsely punctured. Mesothoracic scutum is covered with short, delicate, silver-white hairs, and the scutellum bears a tuft of long, black, stiff bristles. The ovipositor protrudes slightly. Marginal vein long; stigma and postmarginal very short.

Male.—Differs from the female principally in the antennæ; the pedicel is scarcely longer than thick; the succeeding joints to the club are long, slender, distinct, and, with the exception of the first, are each contracted in the middle, and are furnished above with two half whorls of long, diverging hairs; the club is not thicker than the preceding joint, and is shorter than the two preceding joints together. The hairs upon the scutellum are more scattered than in the ♀, and not gathered together in a tuft.

26. (1) **Chiloneurus albicornis** Howard.

A single female of this species was bred, May 7, 1883, from an undetermined species of *Lecanium* collected on *Quercus aquatica*, "water-oak," at Bluffton, S. C., by Dr. J. H. Mellichamp. [C. V. R. Coll.]

In a small collection of chalcids labeled by Walker I find a *Chiloneurus* bearing the label *C. elegans* Dalm., which closely resembles *C. albicornis*, the only difference perceptible (perhaps on account of the poor condition of the specimen) being a darkening of the third and fourth funicle joints. The Walker specimen, however, differs radically from the description of *elegans* in Mayr's revision, and furnishes only another instance of the proverbial carelessness of the English author.

27. (2) **Chiloneurus dubius**, n. sp.

Male.—Length, 1.05^{mm}; expanse, 2.5^{mm}; width of fore wing, 0.37^{mm}. Antennæ light brown; face, honey-yellow, brownish towards vertex; pronotum, mesoscutum, and axillæ black, with silvery-white hairs on pronotum and scutum; axillæ finely punctured; mesoscutellum bright rust-red, with a loose tuft of black hairs at tip; abdomen black, with a coppery luster; fore wings with a small dusky patch below stigma. Front and middle legs light yellowish throughout; hind legs black throughout, with the exception of a whitish femero-tibial articulation and the first three white tarsal joints.

Described from 4 ♂ specimens, parasitic in all probability, on a species of *Lecanium* (probably undescribed) from Scotch and Dwarf Mountain Pine, collected in 1874, at Lancaster, Wis., by A. W. Barber, and later at St. Louis. [C. V. R. Coll.]

28. (3) **Chiloneurus dactylopii**, n. sp.

A large number of specimens of a species of Chiloneurus was bred from a common "mealy bug" (*Dactylopius destructor* Comst.), on the garden Pæonia on the Agricultural Department grounds, at Washington, late in November, 1884. It is impossible to distinguish the female of this species from that of the European *C. formosus* Boh., as I am informed by Dr. Mayr; but the males of the two species are readily distinguishable by the relative lengths of the marginal and stigmal veins. In *formosus* the marginal is twice as long as the stigmal, while in *dactylopii* it is only slightly longer. [Dept. Agr. and C. V. R. Coll.]

Genus Aphycus Mayr.

Female.—Antennæ 11-jointed, moderately short, inserted near the mouth; scape widened or cylindrical; pedicel about twice as long as thick; the joints following the pedicel are thicker than long, and increase in thickness by degrees; the club is about as long as the three preceding joints, and is obliquely rounded, often compressed. Face, vertex, and dorsum of thorax are lusterless and finely punctate, frequently clothed with yellowish hair. Ovipositor usually not protuding. The marginal vein is not developed, and the stigmal is given off at the juncture of the submarginal with the costa.

Male.—Distinguished by the antennæ, in which the pedicel is longer than the succeeding joint (this is so also with the female but not with the males of allied genera). The flagellum is uniformly clothed with hairs; the first joints are longer than thick, and the club only so long as the two preceding joints.

29. (1) **Aphycus brunneus**, n. sp.

Female.—Length, 1.06^{mm}; expanse of wings, 2.12^{mm}; greatest width of fore wings, 0.41^{mm}. Scape of antennæ not broadened; ovipositor slightly exserted. Head very delicately shagreened; mesoscutum, scapulæ, and mesoscutellum thickly but not deeply punctured; punctures of mesoscutum and scapulæ transverse oval, and of scutellum longitudinal oval, converging toward the anterior angle; posterior border of mesoscutellum smooth, as is also the metanotum. General color yellow-brown, yellow below; scape and pedicel of antennæ brown, flagellar joints yellowish, club brown; all coxæ brown; front femora, tibiæ, and tarsi yellowish white, with a faint brownish patch on the dorsal side of femora and tibiæ; middle femora and tibiæ

yellowish white, each with a median brown annulation, tarsi yellow; hind femora and tibiæ brown, white at base of femora and at base and tip of tibiæ, tarsi yellowish white; wing veins yellowish, dusky at origin of stigmal.

Described from 1 ♀ specimen; ♂ unknown.

Bred, November, 1874, from specimens of *Diaspis rosæ* received from Mrs. Mary Treat, Vineland, N. J. [C. V. R. Coll.]

30. (2) **Aphycus ceroplastis**, n. sp.

Female.—Length, 1.4mm; expanse, 3.3mm; greatest width of fore wing, 0.51mm. Antennal scape with a slight expansion below near tip; club flattened, oval. Mesoscutellum with a slight longitudinal median impression; ovipositor well exserted; ocelli form an acute-angled triangle. Color: Antennal scape yellow, with a black stripe near base and another near tip, including the expansion, and broadest on the outside; basal half of pedicel black, distal half light yellow; funicle brownish at joint 1, each joint growing lighter in color to joint 6, which is yellow; club, dark brown, nearly black, sometimes lighter at tip; head and face yellow, with a large brown spot on each cheek, occiput brown; pronotum black, mesoscutum and axillæ yellow, with a dusky shade towards the pronotal border of the mesoscutum; mesoscutellum black, metanotum also black; tegulæ yellow, dusky at tip; abdomen black above, yellowish beneath, especially near base; ovipositor yellow; the conspicuous shields at the sides of the body (which may possibly be homologized with the epimera of the mesothorax) are shiny black, yellow at bases; all legs yellowish: wings hyaline.

Male.—Length, 1.04mm; expanse, 2.4mm; greatest width of fore wings, 0.42mm. Flagellum of antennæ of a uniform light brown; brown spots on cheeks lacking; mesoscutum and axillæ black; hairs on the abdominal spiracles very conspicuous.

Variety a.—In four ♀'s the marked appearance of the mesonotum, produced by the contrast of the yellow mesoscutum and axillæ with the black mesoscutellum and pronotum, was lost by a black shade in the middle of the mesoscutum, and the axillæ were black as in the ♂.

Described from 8 ♀'s, 2 ♂'s, and 4 ♀'s of variety *a*; all bred from scales of *Ceroplastes artemesiæ* Riley MSS., collected in 1879, on Artemesia, at Silver City, N. Mex., by H. H. Rusby. The parasites issued in the latter part of March. [C. V. R. Coll.]

31. (3) **Aphycus maculipes**, n. sp.

Female.—Length, 1.4mm; wing expanse, 3.00mm; greatest width of fore wing, 0.58mm. In all respects, except in size and details of coloration, similar to *Aph. pulvinariæ*, Howard. The scape, which is greatly widened below, is shining black in color, with a white band at base and a white tip. Pedicel black, lighter towards the lateral portion of the tip. Joints 1, 2, 3, and 4 of the funicle black, the inner surface of 4 sometimes lighter; club dark brown. Face and front rust-red and hairless; ocelli coral-red, placed at the corners of an acute-angled triangle; occiput black nearly to the eyes. Anterior face of pronotum black with light yellow sides and a yellow transverse stripe dorsally; dorsal surface of pronotum of a pale bluish color, with whitish hairs, and furnished at each angle with a distinct round black spot. Tegulæ whitish, dusky at tip. Mesonotum ferruginous; metanotum dusky. Abdomen blackish above, with a yellowish border. Venter uniformly light greenish-yellow; legs all yellowish; all tibiæ with a double row of rather small blackish spots above.

Male.—Length, 1.00mm; wing expanse, 2.8mm; greatest width of fore wing, 0.53mm. Differs from the ♀ principally in the antennæ. In the ♂ antennæ the leaf-like expansion of the scape is not so broad, and its white tip and base are more marked; the distal half of the pedicel is white, but the rest of the antennæ, including flagellar joints 5 and 6 and the club, is of a uniform brown thickly clothed with short griseous hairs; the club is faintly yellowish at tip; and seen in certain lights, there is a yel-

lowish tinge on the ventral sides of joints 5 and 6. The abdomen is very short and its dorsum is black with an orange margin in which the black spiracles show very distinctly, each furnished with a few long black hairs. The legs are semitransparent, with the tibial spots not so strongly marked as in the female.

Described from 2 ♂'s and 2 ♀'s, bred May 7, 1883, from a *Lecanium* on the water-oak (*Q. aquatica*) collected at Bluffton, S. C., by Dr. J. H. Mellichamp. The same Lecanium harbored *Chiloneurus albicornis* Howard, and occurs on *Quercus laurifolia* at Mobile, Ala., where it is parasited by *Comys fusca* Howard.

This species seems to be closely related to *Aphycus punctipes* (Dalm.), though the descriptions of the latter are too meager to form a definite idea of it. Certainly the colored figure by Westwood in Stephens's Illustrations of British Entomology (Supplement, Plate XLVI, Fig. 4) cannot be at all correct as to coloration.

Mr. Ashmead's *Coccophagus annulipes* should also be placed in this genus, and will prove closely related to this species, although I have as yet seen but one mutilated specimen.

Two females of what is probably only a variety of this species, having only the first funicle joint brown, are contained in Dr. Riley's collection, and are said to be parasitic on *Attelabus bipustulatus*. With our knowledge of the habits of the genus we can say with almost perfect certainty that these females were not parasitic upon the Attelabus but upon some unnoticed Lecanium attached to the leaves of which the case of the beetle larva was made. [C. V. R. Coll.]

Genus BOTHRIOTHORAX Ratzeburg.

Female.—The body is rather broad and flattened. The antennæ arise not far from the border of the mouth; the scape is quite long and not flattened; the pedicel is as long as or longer than the first funicle joint; this last is as long as or longer than thick the club is shorter than the funicle or (with *B. paradoxus*) twice as long. The face is delicately impressed; vertex and clypeus are very broad, and the ocelli form a very obtuse-angled triangle. The thin (antero-posteriorly) broad (laterally) head is very deeply punctured, as are also mesonotum and scutellum; in the center of each puncture is a little papilla, from which springs a delicate little hair; besides this, there is a leather-like sculpture. The mesonotum and scutellum are rather strongly transversely arched, and the lateral borders of the latter are quite sharp. The ovipositor is not at all, or very slightly, extended. The marginal vein of the hyaline wings is very short or is lacking; the stigmal is long and the postmarginal is short, or very short.

Male.—Very similar to the female and only distinguished by the antennæ and by the sparser punctuation of the head. The pedicel is short, somewhat longer than thick; the funicle quite extended, and the joints small and strongly arched beneath, so that the funicle appears somewhat toothed above; most of the joints have two half whorls of long hair; the club is almost as long as the two last funicle joints together.

32 (1) **Bothriothorax virginiensis**, n. sp.

Female.—Length, 1.63mm; wing expanse, 3.96mm; greatest width of fore wing, 0.69mm. Head rather wider than thorax; lower face densely rugose, but not densely punctulate; front and apex densely covered with large, shallow, round punctures; mesonotum punctured in a similar manner. Stigmal vein given off from submarginal just before it reaches costa; postmarginal very short; antennæ regularly clavate; the pedicel is longer than the first funicle joint, which is a little longer than broad; the remaining funicle joints increase in width and slightly in length; club slightly longer than fifth funicle joint. Color, metallic greenish-black; antennæ jet black; all coxæ metallic; all femora metallic, brownish at tip; front and middle tibiæ brownish-yellow; hind tibiæ greenish-black; all tarsi, yellow.

Described from 1 ♀ specimen collected, September 18, 1881, at Arlington, Va. [C. V. R. Coll.]

The European *Bothriothorax clavicornis* is parasitic on the onion maggot, larva of *Anthomyia ceparum*, and hence, from the remarkable uniformity of habit in this subfamily, we should expect to find that *B. virginiensis* is parasitic upon some Anthomyia here. *A. ceparum* has not been found to be parasited, however, in this country.

33. (2.) **Bothriothorax peculiaris**, n. sp.

Female.—Length, 1.75mm; expanse, 4.25mm; greatest width of fore wing, 0.7mm. Antennæ short, joints not well defined; scape not reaching to top of head; pedicel twice as long as thick, longer than first funicle joint; funicle joints subcylindrical, increasing in diameter from 1 to 6; joint 6 as thick as long; club as long as the three preceding joints together, much flattened and sharply truncate at tip in a somewhat oblique line. Fore wings slightly ciliate at tip; hind tibiæ somewhat compressed laterally; mesoscutellum uniformly punctate. General color blue-green; basal half of antennal scape honey-yellow; distal half black above, yellowish below; flagellum black, clothed with short dense black hairs; front femora black, with green luster, yellow at tip middle and hind femora honey-yellow; front and middle tibiæ honey-yellow; hind tibiæ black; all tarsi honey-yellow.

Male.—Same size and proportions as ♀. Antennæ much longer and more slender than with ♀; pedicel twice as long as thick; joint 1 of funicle three times longer than thick and one-third longer than pedicel; the rest of funicle joints subequal in length, about as long as pedicel, well separated and increasing slightly in thickness. Club flattened, truncate, and nearly as long as the two preceding funicle joints together. In coloration similar to ♀, except that the antennæ and front femora are honey-yellow throughout.

Described from 3 ♀'s and 10 ♂'s.

These were all, with two mutilated specimens, bred in November from a single Syrphid larva found on an oak leaf at Arlington, Va. The larva was honeycombed, as are the hosts of Copidosoma, and all of the parasites issued through two holes cut apparently by two of the most enterprising individuals. [Dept. Agr. and C. V. R. Coll.]

The characters of Bothriothorax will have to be revised. Mayr has described the male of *B. clavicornis* only, and while he shows that the ♂ antennæ of this species differ (p. 82), he rejects Foerster's statement that the club of the ♂ antenna has "eine schief gestutzte, fast heilförmige Gestalt," like the ♀. He says, however, that his varying speci-

mens were incomplete in the antennæ and probably lacked the club, as the ♂ of *B. peculiaris*, resembling the varying individuals in all other respects, have the club described by Foerster.

Genus PSILOPHRYS Mayr.

Female.—The very thin and very long antennæ are given off from the neighborhood of the mouth; the long thin scape reaches nearly to the ocelli; the pedicel is usually more than double as long as thick; the long funicle is extremely thin and filiform and its segments are so closely joined that when the funicle is straight the points of division are very indistinct; the first joints are longer than the last; the first is about twice as long as the pedicel, and the sixth, which is the shortest, is still five times as long as thick; the club is slightly thicker than the funicle, and is longer than the sixth funicle joint, but is shorter than the fifth and sixth together; at the end it is obliquely truncate. The head is not thick (antero-posteriorly), but is long, for the cheeks are somewhat longer than the eyes; the head is not so broad as the thorax. The facial groove is narrow but long and extends up between the eyes as far as their middle; the small keel-shaped facial prominence extends as a delicate carina to the end of the facial groove. The front and vertex form a strong rounded angle and are quite broad. The ocelli form an obtuse-angled triangle, the posterior ocelli lying near the eyes and the sharply-cut occipital border. The thorax is strongly arched transversely and from above appears almost barrel-shaped. The pronotum, mesonotum, scapulæ, and scutellum are closely united; the mesonotum is large and as long as the strong transversely-arched triangular scutellum; the points of the scapulæ meet. The abdominal segments are subequal in length, and the ovipositor protrudes slightly. The fore wings are not ciliate (in this respect differing from all other Encyrtinæ except *Bothriothorax schlechtendali*), and when folded reach only a very little beyond the tip of the ovipositor; the stigmal vein is quite long and arises from the juncture of the submarginal with the costa; the marginal is therefore not developed and the postmarginal is short.

Male.—Very like the female, with a smaller head, very delicately ciliate fore wings, and much thicker, shorter, and differently formed antennæ. The pedicel is only slightly longer than thick; the funicle is thick and clothed with short hairs (although longer than with the female); the first funicle joint is also the longest and the sixth the shortest, but this last is only double as long as thick (the funicle joints usually shrink so much after death that they appear compressed); the club is longer than the first funicle joint, and as thick at its base, gradually more slender, with a rounded summit. The first abdominal segment is longer than any of the others.

34. (1) **Psilophrys hyalinipennis**, n. sp.

Male.—Length, 1.51^{mm}; expanse of wings, 3.02^{mm}; greatest width of fore wing, 0.67^{mm}. Resembles much *Ps. longicornis* (Walk.), of Europe, but differs markedly in the clear transparent wings. Color, metallic bluish-green, abdomen shiny black, antennæ brown; all coxæ metallic, all femora and tibiæ dark brown, with reddish-yellow knees; tarsi, reddish-yellow, with black terminal joints; wing veins strong, dark brown in color.

Described from 1 ♂ specimen. Habitat, Missouri. [C. V. R. Coll.]

Genus Homalotylus Mayr.

Female.—The antennæ are given off near the border of the mouth; the pedicel is somewhat longer than the first funicle joint; the 6-jointed funicle has cylindrical joints, which increase more or less in thickness toward the club; the club is obliquely truncate from the tip to the base, or nearly to the base. The head is thin (fronto-occipitally); the facial groove is very delicate or is wanting (*H. flaminius*). The eyes are much farther apart below than above. The ocelli form an acute or a right-angled triangle. The face, and especially the clypeus, not broad, covered with very fine and thick punctulations, and with larger punctures in rows or irregularly placed. Mesonotum finely shagreened and moderately shining. The axillæ meet only in a point, or are far apart. The ovipositor is hidden. The hind femora have a longitudinal groove for the reception of the hind tibiæ. The marginal vein is very short, or is wanting. The stigmal is rather long.

Male unknown.

35. (1) Homalotylus obscurus, n. sp.

Female.—Length, 1.86^{mm}; wing expanse, 3.8^{mm}; greatest width of fore wing, 0.58^{mm}. Antennal scape, very long and slender; pedicel somewhat more than twice as long as thick; first funicle joint one-third longer than thick; sixth funicle joint a trifle thicker than long; all funicle joints cylindrical, and increasing slightly in thickness and decreasing in length from joint 1 to joint 6; club as long as the preceding three joints together, obliquely truncate from tip quite to base. Facial groove entirely wanting. Ocelli form an acute-angled triangle. The larger punctures of the head are irregularly placed. The axillæ meet at their apices only. First joint of middle tarsus as long as all the succeeding joints together, and only slightly incrassated; middle tibial spur stout, and longer than the first tarsal joint. Color: Antennal scape, pedicel, and funicle black, club yellowish-white; face yellow-brown, with a metallic luster behind the eyes; pronotum and mesoscutum black, with a faint golden luster; mesoscutellum and axillæ dead-black, owing to the very close fine punctures; tegulæ black at tips, brown at bases; metanotum and dorsum of abdomen black; venter of thorax dark honey-yellow, of abdomen black; all coxæ and femora dark brown; all tibiæ black; front and hind tarsi black; middle tarsi, except fifth joint and middle tibial spur, white or yellowish-white. Fore wing with a large subcircular dusky spot in the middle, including stigmal and marginal veins, and with a narrow, clear, hairless streak extending transversely and proximally from marginal vein to near the hinder border of the wing; cilia very short.

Described from 13 ♀ specimens bred from Coccinellid larvæ, in all probability those of *Cycloneda sanguinea* L., at Centreville, Fla., by Mr. H. G. Hubbard. From two to five of the parasites were bred from each of the parasited larvæ. [C. V. R. Coll.]

Of the three European species of *Homalotylus*, the only one whose habits are known, *H. flaminius* (Dalman), lives in Coccinellid larvæ; and Walker (Entom. Mag. V, 1838, p. 54) states that he has bred it from *Galeruca calmariensis*, an insect which, though very abundant, has never been found parasited in this country.

Genus Leptomastix Förster.

Female.—The antennæ are very long, as long as or somewhat longer than the body, slender and clothed with short hairs; the pedicel is twice as long as thick; each of

the three first funicle joints is about double the length of the pedicel, and the three following decrease in length until the sixth is scarcely twice as long as thick; the club is slightly broader than the funicle, is rounded on the end, and is as long as the last two funicle joints together. The facial impression is small, and the forehead extends ne ar) the lower end of the eyes; the vertex is broad, and the ocelli are at the corners of an equilateral tria' '·· both clypus and vertex are very finely punctured. The thorax is moderately arched, the mesonotum somewhat shining and finely shagreened with sparse hair follicles; the scapulæ meet in the middle and form a very short longitudinal carina; the triangular, finely wrinkled scutellum has rather sharp side borders and apex. The upper side of the abdomen is very delicately punctured and the segments are difficult to distinguish; seen from the side they appear subequal in length. The marginal vein of the fore wing is somewhat longer than the stigmal, which is nearly equal in length to the postmarginal. The ovipositor is usually considerably protruded. The legs are longer than usual, and the middle tibial spur is very strong and prominent.

Male.—The male is to be principally distinguished by its antennæ, which are considerably longer than the whole body. The relative proportion of the joints is about the same as in the female, except that the pedicel is very conical and only about as long as thick; the funicle joints are well separated by dorsal incisions, and each is very slightly constricted in the middle above; the funicle is furnished with a number of long hairs, which are not arranged in whorls.

This striking genus was founded by Förster in 1852, and in the characterization of the female I have followed Mayr quite closely. Dr. Mayr, however, had before him but one specimen (♀), and as my material is extensive, I have made one or two changes. I have added a description of the male which was unknown to both Förster and Mayr. The genus was founded on antennal characters, but may be recognized at a glance from the length and strength of the middle legs.

36. (1) Leptomastix dactylopii, n. sp.

Female.—Length, 1.51mm; expanse, 3.6mm; greatest width of fore wing, 0.6mm. General color honey-yellow, with a slight reddish tinge on the mesonotum; eyes, antennæ (with the exception of a slight ventral yellow streak), occiput, immediately behind the eyes, black; metascutum, posterior margin of pronotum, dorsum of abdomen, dorsal surface of posterior femora, more or less dusky.

Male.—Length, 0.97mm; expanse, 2.65mm; greatest width of fore wing, 0.46mm. In effect darker than female, and quite variable in the amount of black with which the dorsum of the thorax is ornamented. The mesoscutum is always yellow, but the scapulæ are often very dark and the mesoscutellum has often a dark median stripe; the hind tibiæ and tarsi are also dark.

This species is described from many specimens of both sexes bred in October and November, 1884, from *Dactylopius destructor* Comst., infesting Pæonia on the Department grounds at Washington, D. C., in company with *Chiloneurus dactylopii*. It is very similar to *Leptomastix histrio*, judging from Mayr's description of the latter, and the difference may arise from the fact that *histrio* was described from a single speci-

men, while the specimens which I have show considerable colorational variation.*

The appearance of this parasite upon the destructive mealy bug is to be welcomed. A large colony of the latter insect was completely destroyed by this *Leptomastix* and the *Chiloneurus* just mentioned. It is possible that both are recent introductions; at all events, neither has ever been bred from *Dactylopius* here before, and we shall watch for them another season with interest.

Subfamily APHELININÆ.

The two genera mentioned under this subfamily may be separated as follows:

A. Fore wings with a hairless line extending from stigma transversely towards base of wing .... APHELINUS.
B. Fore wings with no such line .... COCCOPHAGUS.

Genus COCCOPHAGUS Westwood.

Antennæ 8-jointed; scape rather short and stout; pedicel one-third the length of scape and of about the same thickness; joints 3, 4, and 5 increase very slightly or not at all in thickness and decrease in length; club very plainly 3-jointed, a little longer than the preceding two joints. Mesoscutum large, its posterior broader, with a slight re-entering angle; sutures between parapsides and scapulæ very oblique. Mesoscutellum nearly as long as broad, rounded behind, the fore part forming three sides of a hexagon, the side bordering on the scutum a little shorter than the other two; wings equally hairy, except at base; no hairless line. Stigma small, but plainly visible, subtriangular in form. Middle tibial spur usually not as long as first tarsal joint, often curved. Species usually of somber colors, often of two contrasting colors, black and yellow.

37. (1) **Coccophagus vividus**, n. sp.

Female.—Length, 1.03^{mm}; wing expanse, 1.96^{mm}; greatest width of fore wing, 0.35^{mm}. General color shiny black; antennæ light brown, with the customary dark brown longitudinal carinæ; greater part of mesoscutellum and visible portion of metascutellum bright orange-yellow, the line of juncture of the two colors on the mesoscutellum slightly irregular but not curved; tegulæ yellow; all coxæ and femora brown, yellow at joints; all tibæ and tarsi yellow, occasionally a dusky patch near base of hind tibæ, and the fifth tarsal joint is of course brown. Entire mesonotum finely punctate.

Male.—Length, 0.55^{mm}; wing expanse, 1.47^{mm}; greatest width of fore wing, 0.25^{mm}. Color as in female, except that the tegulæ are brown and the scutellar spot is dull lemon-yellow, as large proportionally as in ♀, but not so vivid.

Described from 1 ♂ and 3 ♀'s bred from *Lecanium hesperidum* on orrange, Crescent City, Fla., by H. G. Hubbard. [Dept. Agr. Coll.]

* Since the above was written I have received from Dr. Mayr the following concerning this species:

"Was nun Ihre letzte Sendung betrifft, so steht Ihr Leptomastix Dactylopii der europäischen Art sehr nahe, und wenn Ihre Exemplare nicht etwa durch unnatürliche Verhältnisse der Zucht im Zimmer besonders klein und unentwickelt geblieben sind, so kann Ihr Leptomastix ganz gut als eigene Art betrachtet werden, wenn auch die Unterschiede nur in der Grösse und Farbung vorhanden sind."

38. (2) **Coccophagus flavifrons**, n. sp.

Male.—Length, 1^{mm}; wing expanse, 2^{mm}; greatest width of fore wing, 0.35^{mm}. Color: Eyes, clypeus, occiput, abdomen, and dorsum of thorax black, with a pronounced bluish-metallic luster on abdomen; face, antennal scape, all legs, except hind tibæ, lemon-yellow; flagellum of antennæ brown; tegulæ orange-yellow; hind tibæ brown, with yellowish extremeties; wing veins fuscous.

Described from 1 ♂ specimen; ♀ unknown; bred, April 6, 1882, from *Lecanium* sp. on *Pinus australis*, collected at Archer, Fla. Two other ♂ specimens, nearly agreeing with this species, but each lacking the head are in the collection. [C. V. R. Coll.]

39. (3) **Coccophagus cognatus** Howard.

One ♂ and 1 ♀ of this species were bred, April 2, 1881, from *Lecanium* sp. upon leaves of *Melia azederach*, collected by Mr. G. W. Latimer, at Eufaula, Ala. [C. V. R. Coll.]

40. (4) **Coccophagus koebelei**, n. sp.

Male.—Length, 0.84^{mm}; wing expanse, 1.59^{mm}; greatest width of fore wing, 0.34^{mm}. Color: Eyes, head, face, tegulæ, all thorax (except tips of meso and metascutelli), and abdomen shiny black; antennæ light brown, scape black; all tibiæ, tarsi (except last joint), and tips of femora lemon-yellow; all tibæ, except at tips, black; tips of meso and metascutelli orange-yellow; the line between the black and the yellow sharp and distinct, and convex posteriorly.

Described from 1 ♂ specimen; ♀ unknown; bred, April 6, 1882, from *Lecanium* sp. on *Pinus australis*, collected at Archer, Fla., by Mr. A. Koebele, to whom the species is dedicated. [C. V. R. Coll.]

Genus APHELINUS Dalman.

Antennæ 8-jointed; scape long and slender; pedicel large, subconical; joints 3 and 4 very small; joint 5 as long as pedicel, subcylindrical; club large, with several minute bristles at tip. Mesoscutum wider than long; parapsides distinctly separated, small. Mesoscutellum very broad and short; subfusiform, unicolorous. Middle tibial spur slender, as long as first tarsal joint. Fore wings each with an oblique hairless line extending from the stigma backwards to the posterior border of the wing. Stigma small and inconspicuous, club-shaped, rounded at tip. Species generally unicolorous, either yellow or blackish, very seldom metallic.

41. (1) **Aphelinus diaspidis** Howard.

Nine females of this species were bred from a *Mytilaspis* on an Orchid, an undetermined species of *Dycaste* from Japan; received February 6, 1874, from Mr. George Thurber, of the American Agriculturist. [C. V. R. Coll.]

42. (2) **Aphelinus mali** (Haldeman.)

Three ♀'s of this species were bred at Washington, February 8 and 15, 1879, from *Schizoneura lanigera* Hausm. [C. V. R. Coll.]

Subfamily ELACHISTINÆ.

The two genera mentioned under this subfamily may be separated as follows:

A. Posterior tibiæ with two spurs.......................................EUPLECTRUS.
B. Posterior tibiæ one-spurred..ELACHISTUS.

Genus EUPLECTRUS Westwood.

Head triangular; eyes prominent. Antennæ inserted below middle of face; scape long; funicle 4-jointed. Thorax highly developed; mesonotum with a median longitudinal carina. Abdomen with a moderate, cylindrical petiole. Posterior tibiæ with two very long spurs. Body not metallic, but of dark color; head and thorax with sparse, coarse hairs.

43. (1) **Euplectrus comstockii** Howard.

Male.—Length, 1.98mm; wing expanse, 4.3mm; greatest width of fore wing, 0.8mm. Face triangular, narrowing sharply below eyes, smooth and glistening, with a very few punctures; antennal scape slender, not widened. Pronotum very rugose, except at posterior border; mesoscutum somewhat transversely rugose, with a strongly-marked median longitudinal carina; mesoscutellum smooth; metathoracic carina very pronounced and dividing posteriorly; metatibial spine nearly as long as first two tarsal joints. Abdomen broadening from base and subtruncate at tip. General color shining black with long stiff whitish hairs scattered over thorax; labrum honey-yellow; antennal scape light honey yellow, flagellum gradually darker, club quite dark at tip; all legs honey-yellow; abdomen with a dorsal yellow spot entirely bounded with black and of an irregular pyramidal shape, the base of the pyramid towards tip of abdomen; venter yellow-brown along median line

Female.—Slightly larger; abdomen more nearly ovate.

Described from many ♂ ♀ specimens bred from half-grown larvæ of *Aletia xylina* (Say) in Mississippi, Alabama, and Florida. [C. V. R. and Dept. Agr. Coll.]

(See Report Department of Agriculture, 1880, Plate II, Fig. 4. See also Can. Ent., XII, p. 159, and Am. Naturalist, 1881, p. 16.)

44. (2) **Euplectrus leucotrophis**, n. sp.

Male.—Length, 1.25mm; wing expanse, 2.91mm; greatest width of fore wing, 0.58mm. Differs from *E. comstockii* in the following points: Mesoscutum very rugose; median carina scarcely visible; face, below eyes, and scape of antennæ nearly white, slightly yellowish; all legs, including coxæ, semi-transparent, whitish in color; the dorsal abdominal yellow spot extends to pedicel, and at its base widens out to include the lateral borders of the abdomen; the venter is yellowish near base; elsewhere dark brown, nearly black.

Described from 3 ♂ specimens bred from unknown Arctiid larva, July 19, 1880, received from Dr. R. S. Turner, Fort George, Fla. [Dept. Agr. Coll.]

45. (3) **Euplectrus platyhypenæ**, n. sp.

Female.—Length, 1.67mm; wing expanse, 3.8mm; greatest width of fore wing, 0.6mm. Differs from *E. comstockii* as follows: Pronotum markedly shagreened; mesoscutum only slightly roughened; median carina distinctly visible; hind border of abdomen well rounded. Color: Face entirely black; legs dark honey-yellow; hind coxæ

quite dark at bases; yellow blotch on dorsum of abdomen, occupying nearly its whole surface, leaving only a narrow band of black around the edge; venter the same.

Male.—Rather smaller than the ♀, but agrees otherwise, except that the scape of the antennæ has a ventral leaf-like expansion; the abdomen is even more rounded than in the ♀, and the yellow blotch is much smaller.

Described from 1 ♂ and 1 ♀ bred, July 11, 1882, from the larva of *Platyhypena scabra* (F.), District of Columbia. [C. V. R. Coll.]

46. (4) **Euplectrus catocalæ**, n. sp.

Length, 2.3mm; expanse of wings, 4.3mm; greatest width of fore wing, 0.7mm. Differs from *E. comstockii* in its larger size, more rounded abdomen, and in the appearance of the abdominal blotch. This in the ♂ occupies the whole of the anterior half of the dorsum of the abdomen, while the venter is entirely yellow except at tip. With the ♀ the spot occupies the anterior center of the dorsum of the abdomen, is oval in form, and is bounded on all sides by a broad margin of dark brown; the venter is as with the ♂. The metascutellum is finely striated longitudinally. The yellow spot on the lower front extends to the base of the antennæ.

Described from 3 ♂'s and 2 ♀'s bred, July 5, 1873, from the larva of a species of *Catocala* at Saint Louis, Mo. [C. V. R. Coll.] This species has also been bred from a geometrid larva on birch, found at Hyattsville, Md., July 9, 1882. [Dept. Agr. Coll.]

47. (5) **Euplectrus frontalis**, n. sp.

Female.—Length, 2mm; wing expanse, 4.7mm; greatest width of fore wing, 0.81mm. In this species the sculpture of the thorax is more definite than in any other so far considered. The pronotum is deeply but sparsely punctuate except at its posterior border; the mesoscutum is quite coarsely shagreened, and its median carina is faint; the metascutellum is plainly longitudinally striate. The yellow spot of the lower front includes the bases of the antennæ, but the cheeks below this point are black to the bases of the mandibles. In other respects it resembles *E. catocalæ*.

Described from 1 ♀, bred, September 13, 1882, from an unknown noctuid larva on walnut, collected at Arlington, Va. [C. V. R. Coll.]

Genus ELACHISTUS Spinola.

Antennæ inserted considerably below the middle of the face, flagellum very rarely incrassate; funicle 4-jointed; club 2-jointed. Thorax with a large conico-semiglobose pronotum; mesoscutum short; mesoscutellum with two longitudinal grooves, meeting at the apex; metanotal median carina acute. Fore wings with the postmarginal vein plainly longer than the stigmal; stigmal club small but with an acute uncus. Abdomen usually with a short smooth petiole. Posterior tibiæ 1-spurred. Body black, immaculate; head always more or less metallic.

48. (1.) **Elachistus proteoteratis**, n. sp.

Female.—Length, 1.86mm; wing expanse, 3.12mm; greatest width of fore wing 0.53mm. Head broadly oval, cheeks well rounded, antennal fossæ converging dorsally; the sutures of the mesoscutar parapsides and of the scapulæ are continuous; the postmarginal vein is rather longer than the stigmal, which is very straight, with a small club and a sharp claw. Face smooth; occiput and top of head near eyes slightly punctulate; pronotum sparsely punctured, except at its smooth posterior border; mesoscutum transversely shagreened; mesoscutellum very finely coriaceous; meta and post-

scutelli smooth; metathoracic carina delicate; petiole rather short, cylindrical, and rugose; abdomen elliptical, concave above, convex below. Pronotum and mesoscutum with many white hairs; a longitudinal row of long delicate white hairs on the metapleura of each side. Color, dark metallic-green; scape of antennæ nearly white, flagellum, light ochre-yellow; mouth parts nearly white, mandibles shining brown at tips; all legs yellowish-white, except hind coxæ, which are brownish near base; basal half of abdomen above with a bright straw-colored blotch, bounded by brown and ending posteriorly in a straight transverse line; venter of abdomen with a longitudinal honey-yellow stripe, wider anteriorly than posteriorly.

Described from 3 ♀'s bred, in June, 1873, from larvæ of *Proteoteras æsculana* Riley, at Kirkwood, Mo. [C. V. R. Coll.]

49. (2) **Elachistus cacœciæ**, n. sp.

Male.—Length, 1.93mm; wing expanse, 3.84mm; greatest width of fore wing, 0.74mm. Face subtriangular, cheeks nearly straight; mesoscutar and scutellar furrows not continuous, interrupted by the angle of the scapulæ; postmarginal vein much longer than stigmal. Head and eyes quite thickly covered with short, fine, dusky hairs, pronotum and mesoscutum furnished with longer and stouter dark hairs. Head sparsely punctured with transverse oblique lines on vertex and clypeus; occiput very finely and thickly punctured; scutellum smooth, and mesoscutum only slightly shagreened. Color shining black, not metallic; scape of antennæ whitish below, dark brown above, flagellum dark brown, with short, dense, whitish hairs; mandibles light reddish-brown; all legs yellowish-white, hind coxæ slightly darker at base; first two joints of abdomen above with a yellowish-brown spot extending nearly to lateral edges, venter light brown at base.

Described from 6 ♂'s bred, August, 1877, from the leaf curl of *Cacœcia rosaceana* (Harr.), at Kirkwood, Mo. [C. V. R. Coll.] One ♀ specimen of apparently the same species was bred at Washington, from *Hyphantria textor*, upon which it fed externally. The adult made its appearance October 29, 1881. [Dept. Agr. Coll.]

50. (3) **Elachistus coxalis**, n. sp.

Female.—Length, 2.21mm; wing expanse, 4.34mm; greatest width of fore wing, 0.7mm. Resembles *E. proteoteratis* very closely, but differs in size, as just indicated, and also presents the following colorational differences: The posterior coxæ have upon their outer basal portion a large definite metallic-green spot, which in *proteoteratis* is only faintly indicated; the middle coxæ are also faintly green at base; superior surface of antennal pedicel tinged with dark brown, superior portion of all the flagellar joints darker than inferior surface; metapleural hairs long and conspicuous; ventral yellow stripe very narrow near tip of abdomen.

Described from 1 ♀ caught on window at Washington, D. C., January 14, 1881. [C. V. R. Coll.]

Subfamily ELASMINÆ.

Head subglobose: front sparingly but strongly punctate. Funicle of antennæ 3-jointed. Thorax: Pronotum short, parapsides not distinguishable, mesoscutellum depressed, metascutellum membraneous white. Wings narrow, marginal vein long, stigmal very short, almost punctiform, postmarginal distinct. Abdomen sessile, with a compressed venter. Legs becoming gradually longer and stronger; posterior coxæ very large, tibiæ 2-spurred at tip. Antennæ of the male with three branches.

Genus ELASMUS Westwood.

Head, antero-posteriorly rather narrow, vertex subacute, eyes suboval, ocelli placed in a triangle. Antennæ inserted below the middle of the face, scape not reaching to ocelli, flagellum not incrassate. Thorax with obsolete punctures, sutures of the scutellum delicate, metathorax with no carina, apex not perpendicular. Costa of the wings shorter than the marginal, costal cell very narrow. Abdomen triangular, terebra scarcely observable. Posterior tibiæ spinous underneath. Mesosternum smooth. Epistoma not distinguishable, epimera nearly triangular. Body black, metallic above.

Thomson in his remarks after the generic diagnosis of *Elasmus* says, "Arterna lefva parasitiskt på Microgaster"—a general statement. Ratzeburg, however, gives *Aneure rhipiccros* Först. as parasitic on *Psyche graminella;* Giraud gives *E. flabellatus* Westw., as parasitic on the same species and on *Epichnopteryx helix*, and *E. nudus* Nees, as destroying *Cecidomyia rosaria.* Of the following species all are represented in notes as having been bred from Tineid larvæ except *E. albicoxa*, which was found in a jar with the eggs of *Limnitis dissippus*, from which it could not possibly have come. Microgasters were bred from the young larvæ of *L. dissippus*, and, in default of careful notes, it is very possible that the specimen of *E. albicoxa* may have come from one of the Microgaster cocoons. In the same way Microgasters were bred from the Tineids on Rhus and Apple, from which *E. varius* and *E. pullatus* are stated in the notes to have been bred, and the mere entry in the note-book will not weigh against a unity of habit in the genus if such can be shown to be probable. Thomson does not give his data, but the fact that Microgasters were bred in the cases mentioned would have seemed to afford a strong probability of such an unity of habit, had it not been that the last species of the genus, *E. tischeriæ*, was bred under my eyes, and watched with the desire to determine this point in mind. Not only was no Microgaster observed, but the *Elasmus* larvæ was several times found feeding externally, just prior to pupation, upon the larvæ of the Tischeria. This observation will transfer *Elasmus* from the ranks of injurious insects to those of beneficial.

51. (1) **Elasmus varius**, n. sp.

Male.—Length, 1.75^{mm}; wing expanse, 3.30^{mm}; greatest width of fore wing, 0.33^{mm}. Head coarsely and densely punctate, the impressions more sparse upon the face. Mesonotum covered with long delicate hairs, and appearing as if covered with minute overlapping scales. Scutellum apparently smooth, but, under a high power, covered with fine wavy lines, and furnished near base with hairs. Abdomen long, slender, acuminate, furnished at tip with a number of stiff black hairs. General color shining black; rounded tip of metascutellum orange-yellow; metascutellar appendage* membranous white, rest of metanotum metallic-green; first abdominal joint dorsally, striped with two transverse shaded bands of ochre-yellow; venter of abdomen ochre-yellow except at tip; front coxæ black at base, remainder brownish-yellow; femora brown-

* "Das schildchen hat an der Spitze einen häutigen, drieckigen, ziemlich scharf zugespitzten, lamellenartigen Anhang." (Förster Hymenopt. Stud. II, p. 71.)

ish-yellow, shaded dorsally with brown; tibiæ yellow; tarsi fuscous; middle coxæ black at base, rest brownish-yellow; femora black with metallic luster, and with a ventral longitudinal yellow line; tibiæ yellowish, with a dorsal dusky streak; tarsi dark fuscous; hind coxæ and femora shining black, light at joints; tibiæ dirty yellow, lined dorsally with brown; tarsi blackish; antennæ black with light hairs; wing veins dark brown.

Described from 4 ♂ specimens (♀ unknown) bred, July 20, 1872, at Saint Louis, Mo., from the leaf curl of a miner and roller on *Rhus copallina*, probably *Gracillaria rhoifoliella* Cham. [C. V. R. Coll.]

52. (2) **Elasmus nigripes**, n. sp.

Male.—Length, 1.58^{mm}; wing expanse, 2.91^{mm}; greatest width of fore wing, 0.27^{mm}. Differs from *E. varius* in size and relative width of fore wing. The scutellar spot is small and narrow, and is not of so vivid an orange color as in *E. varius*. The front coxæ are black, femora and tibiæ earthy yellow, with many black hairs, which on the femora obscure the real color; tarsi dusky; middle and hind coxæ, femora, tibiæ and tarsi nearly black.

Described from 1 ♂ (♀ unknown) bred, from *Lithocolletis gregariella* Murtfeldt, at Kirkwood, Mo., by Miss Murtfeldt, 1881. [C. V. R. Coll.]

53. (3) **Elasmus albicoxa**, n. sp.

Male.—Length, 2.00^{mm} (?); wing expanse, 4.28^{mm}; greatest width of fore wing, 0.48^{mm}. The specimen from which this description is drawn has lost its abdomen, but the other characters are sufficiently marked to found a species. It differs from the preceding species in the following points: The front is coarsely and sparsely punctured, but the punctures are more evenly distributed than in *E. varius*, extending down upon the face. The scutellar spot is broad and includes the tip of the mesoscutellum as well as the metascutellum. The leg coloration is as follows: Front coxæ nearly pure white, slightly tinged with brownish just at base; femora yellowish-white, with a longitudinal streak of brown on the dorsal outer side; tibiæ tinged with brown, tarsi dusky; proximal half of dorsal surface of middle and hind coxæ shiny black, rest white; femora yellowish-white, with a longitudinal blackish streak; tibiæ whitish, with fine brown longitudinal lines; tarsi nearly black.

Described from 1 ♂ (♀ unknown) found in jar with eggs of *Limenitis dissippus* Godt., at Kirkwood, Mo., 1871 (?). [C. V. R. Coll.]

54. (4) **Elasmus pullatus**, n. sp.

Male.—Length, 1.39^{mm}; wing expanse, 3.49^{mm}; greatest width of fore wing, 0.46^{mm}. Entire surface of body shining black in color, except the antennal pits and the immediate region of the mouth parts, which are honey-yellow; all coxæ and femora black, except that the femora are tipped with yellow-brown; anterior tibiæ yellowish; tarsi dusky; middle and hind tibiæ yellow-brown at tip; tarsi dark.

Described from 1 ♂ (♀ unknown); bred from Tineid leaf miner on apple (*Tischeria malifoliella* ?) at Kirkwood, Mo., April 1, 1871. [C. V. R. Coll.]

55. (5) **Elasmus tischeriæ**, n. sp.

Female.—Dimensions the same as with *E. varius*. Differs from this species in the following respects: Head less densely punctate and mesonotum more markedly scaly in appearance. Scape of antennæ light yellow. Metanotum and base of first joint of abdomen metallic-green. Abdomen with a continuous longitudinal dorsal black stripe, which widens on the last segment and includes the ovipositor; remainder of

the abdomen honey yellow. Front coxæ dirty white, tibiæ and tarsi the same; middle and hind coxæ nearly black, honey-yellow at either end. Wing veins slightly dusky, not dark brown.

Described from 10 ♀ specimens (♂ unknown) bred from larvæ of *Tischeria solidaginifoliella* mining leaves of Solidago in District of Columbia and Northern Virginia. The adult parasites issued August 16, 17, and 19, 1884. [Dept. Agr. and C. V. R. Coll.]

LIST OF HOSTS AND PARASITES.

LEPIDOPTERA.

Aletia xylina	*Chalcis ovata.* *Euplectrus comstockii.*
Antheræa polyphemus	*Spilochalcis mariæ.*
Apatura clyton	*Chalcis ovata.*
Arctiid larva (unknown)	*Euplectrus leucotrophis.*
Attacus cynthia	*Spilochalcis mariæ.*
Botis alnialis	*Chalcis ovata.*
Bucculatrix pomifoliella	*Encyrtus bucculatricis.* *Cirrospilus flavicinctus.*
Bucculatrix n. sp. on Oak	*Encyrtus bucculatricis.*
Cacœcia rosaceana	*Chalcis ovata.* *Elachistus cacœciæ.*
Callosamia promethia	*Spilochalcis mariæ.*
Catocala sp	*Euplectrus catocalæ.*
Celæna renigera	*Copidosoma celænæ.*
Desmia maculalis	*Chalcis ovata.*
Gelechia gallæ-asterella	*Copidosoma intermedium.*
gallæ-solidaginis	*Copidosoma gelechiæ.* *Chalcis ovata.*
pseudacaciella	*Copidosoma vagum.*
Gracillaria rhoifoliella	*Elasmus varius.*
Lagoa opercularis	*Chalcis robusta.*
Lithocolletis gregariella	*Elasmus nigripes.*
Papilio cresphontes	*Chalcis robusta.*
Platyhypena scabra	*Euplectrus platyhypenæ.*
Proteoteras æsculana	*Elachistus proteoteratis.*
Samia cecropia	*Spilochalcis mariæ.*
Thyridopteryx ephemeræformis	*Chalcis ovata.* *Spilochalcis mariæ.*
Tischeria malifoliella	*Elasmus pullatus.*
solidaginifoliella	*Elasmus tischeriæ.*

HEMIPTERA.

Aspidiotus subcorticis	*Encyrtus ensifer.*
Ceroplastes artemesiæ	*Aphycus ceroplastis.*
Dactylopius destructor	*Chiloneurus dactylopii.* *Leptomastix dactylopii.*
Diaspis rosæ	*Aphycus brunneus.*
Lecanium hesperidum	*Coccophagus viridus.*
Lecanium sp. on Scotch pine	*Chiloneurus dubius.*
Lecanium sp. on Quercus aquatica	*Chiloneurus albicornis.* *Aphycus maculipes.* *Comys fusca.*

Lecanium sp. on Pinus australis	*Encyrtus sublestus.* *Coccophagus flavifrons.* *Coccophagus koebelei.*
Lecanium sp. on Melia azederach	*Coccophagus cognatus.*
Mytilaspis sp. on Dycaste sp	*Aphelinus diaspidis.*
Pachypsylla celtidis-gemma	*Encyrtus pachypsyllæ.*
Schizoneura lanigera	*Aphelinus mali.*
Trioza diospyri	*Encyrtus trioziphagus.*
Trioza magnoliæ	*Encyrtus solus.*

COLEOPTERA.

Cycloneda sanguinea	*Homalotylus obscurus.*
Odontota scutellaris	*Spilochalcis odontotæ.*

HYMENOPTERA.

Pezomachus minimus	*Spilochalcis albifrons.*

DIPTERA.

Cecidomyia salicis-siliqua	*Encyrtus cecidomyiæ.*
Syrphid larva on oak	*Bothriothorax peculiaris.*
Tachina sp	*Chalcis tachinæ.*

LIST OF THE DESCRIBED NORTH AMERICAN SPECIES OF THE FAMILY CHALCIDIDÆ.

Family CHALCIDIDÆ.

Subfamily LEUCOSPINÆ.

Genus LEUCOSPIS Fabr.

AFFINIS *Say;* Leconte's Edition of Say's Writings, i, p. 220. Pennsylvania.

APICALIS *Cresson;* Transactions of the American Entomological Society, iv (1872–'73), p. 30. Mexico.

AZTECA *Cresson; ibid.*, p. 33. Mexico.

BASALIS *Klug;* MSS., *Westw.*, Germar's Zeitschrift für Entomologie, i, p. 264, North America.

BULBIVENTRIS *Cresson;* Transactions of the American Entomological Society, iv (1872–'73), p. 29. Mexico.

DUBIOSA *Cresson; ibid.*, p. 34. Mexico.

FRATERNA *Say;* Leconte's Edition of Say's Writings, ii, p. 718. Indiana.

INTEGRA *Haldeman;* Proceedings Academy of Natural Sciences, Philadelphia, 2, p. 53. Pennsylvania.

KLUGII *Westwood;* Germar's Zeitschrift für Entomologie, i, p. 249; tab. 3, fig. 1. Mexico.

MEXICANA *Walker;* Journal of Entomology, i, p. 20. Mexico.

POEYI *Guérin;* Iconographie du Règne Animal, iii, p. 414. Cuba.

SHUCKARDI *Westwood;* Entomological Magazine, ii, p. 213. North America.

SUBNOTATA *Westwood; ibid.*, p. 215. Nova Scotia.

SUMICHRASTII *Cresson;* Transactions of the American Entomological Society, iv (1872–'73), p. 31. Mexico.

TEXANA *Cresson; ibid.*, p. 31. Texas.

TOLTECA *Cresson; ibid.*, p. 34. Mexico.

Subfamily CHALCIDINÆ.

Genus SMICRA Spinola.

ABDOMINALIS *Walker;* Journal of Entomology, i, p. 177. Mexico.

ALBIFRONS (*Walsh*); Insects Injurious to Vegetation in Illinois, p. 37, fig. 8. Illinois.

AMBIGUA *Cresson;* Transactions of the American Entomological Society, iv, p. 44. Mexico.

AMOENA (*Say*); Leconte's Edition of Say's Writings, ii, p. 719. Indiana.

AMPYX *Walker;* Annals and Magazine of Natural History, 2d ser., 5, p. 129. West Indies.

ARCANA *Cresson;* Transactions American Entomological Society, iv, p. 44. Delaware.

AZTECA *Cresson; ibid.*, p. 51. Mexico.

BARBARA *Cresson; ibid.*, p. 47. Texas.

BIOCULATA *Cresson; ibid.*, p. 43. Texas.

BRACATA *Cresson; ibid.*, p. 46. Massachusetts.

CANADENSIS *Cresson; ibid.*, p. 39. Canada.

CAPTIVA *Smith*; Transactions of the Entomological Society of London, 3d ser., i, p. 42. Panama.

CARDINALIS *Cameron*; Biologia Centrali-Americana, Part xxviii, February, 1884, p. 84 (Tab. v, Fig. 5). Bugaba, Panama.

CENTRALIS *Cameron*; *ibid.*, p. 89 (Tab. v, Fig. 6). Presidio, Mexico.

CHAMPIONI *Cameron*; *ibid.*, Part xxvii, December, 1883, p. 80 (Tab. v, Fig. 1). Bugaba, Panama.

COCCINATA *Cresson*; Transactions American Entomological Society, iv, p. 48. Mexico.

COCCINEA *Cresson*; Proceedings Entomological Society of Philadelphia, iv (1865), p. 91. Cuba.

COMPACTILIS *Cresson*; Transactions American Entomological Society, iv, p. 50. Mexico.

CONJUNGENS *Walker*; Notes on Chalcidiæ, Part iii (1871), p. 53. Mexico.

COXALIS *Cresson*; Transactions American Entomological Society, iv, p. 45. Delaware.

DEBILIS *Say*; Leconte's Edition of Say's Writings, ii, p. 720. Indiana.

DECEM-PUNCTATA *Ashmead*; Transactions American Entomological Society, ix (1882), p. xxix. Florida.

DELICATA *Cresson*; Transactions American Entomological Society, iv, p. 54. Texas.

DELIRA *Cresson*; *ibid.*, p. 41. Texas.

DELUMBIS *Cresson*; *ibid.*, p. 40. Massachusetts; Delaware.

DIMIDIATA *Sichel*; Annales de la Société Entomologique de France, 4th ser., v, p. 390. Mexico.

DIVISA *Walker*; Journal of Entomology, i, p. 178. Mexico.

DORSATA *Cresson*; Transactions of the American Entomological Society, iv, p. 49. Texas.

DORSIMACULATA *Cameron*; Biologia Centrali-Americana, Part xxviii, February, 1884, p. 95. Guatemala.

DORSIVITTATA *Cameron*; *ibid.*, p. 90 (Tab. v, Fig. 2). Panama.

ENCAUSTA *Cresson*; *ibid.*, p. 46. Colorado.

ERYTHRINA *Walker*; Journal of Entomology, i, p. 179. Mexico.

EUBULE *Poey*, MSS., *Cresson*; Proceedings Entomological Society, Philadelphia, iv (1865), p. 93. Cuba.

EXORNATA *Cresson*; Transactions American Entomological Society, iv, p. 50. Mexico.

FERRUGINEA *Cameron*; Biologia Centrali-Americana, Part xxviii, February, 1884, p. 84. Guatemala.

FIDIUS *Walker*; Annals and Magazine of Natural History, 2d ser., 5, p. 129. West Indies.

FLAMMEOLA *Cresson*; Transactions American Entomological Society, iv, p. 48. Mexico.

FLAVOPICTA *Cresson*; Proceedings Entomological Society, Philadelphia, iv (1865), p 99. Cuba.

FLEBILIS *Cresson*; Transactions American Entomological Society, iv, p. 39. Massachusetts.

FULVESCENS *Walker*; Entomological Magazine, ii, p. 25. North America.

FULVO-MACULATA *Cameron*; Biologia Centrali-Americana, Part xxviii, February, 1884, p. 93. Bugaba, Panama.

FULVO-VARIEGATA *Cameron*; *ibid.*, p. 92. Presidio, Mexico.

GENICULATA *Cameron*; *ibid.*, p. 87 (Tab. v, Fig. 4). Presidio, Mexico.

GIGANTEA *Ashmead*; Canadian Entomologist, xiii (1881), p. 90. Florida.

GUNDLACHII *Cresson*; Proceedings Entomological Society, Philadelphia, iv (1865), p. 93. Cuba.

IGNEA *Cresson*; *ibid.*, p. 92. Cuba.

IMMACULATA *Cresson*; *ibid.*, p. 97. Cuba.

INTERMEDIA *Cresson*; *ibid.*, p, 92. Cuba.

JUXTA *Cresson*; Transactions American Entomological Society, iv, p. 54. Mexico.

LAMYRUS *Walker*; The Entomologist (1841), p. 337. Mexico.

LAUTA *Cresson;* Transactions American Entomological Society, iv, p. 45. Mexico.
LECTA *Cresson; ibid.*, p. 44. Mexico.
LENTA *Cresson; ibid.*, p. 52. Mexico.
MACULATA (*Fabricius*); Systema Entomologiæ, ii, p. 198. New York (Walker).
MACULICOLLIS *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 88 (Tab. v, fig. 7). Chiriqui, Panama.
MACULIPENNIS *Cameron; ibid.*, p. 92. Chiriqui, Panama.
MARLÆ (*Riley*); American Entomologist, ii, p. 101 (Febr., 1870). United States, east of the Mississippi.
MENDICA *Cresson;* Transactions American Entomological Society, iv, p. 41. Mexico.
MEXICANA *Cresson; ibid.*, p. 42. Mexico.
MINIATA *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 85. Nicaragua; Guatemala.
MIRABILIS *Cresson; ibid.*, p. 53. Georgia; Texas.
MIRANDA *Cresson; ibid.*, p. 49. Mexico.
MISSOURIENSIS (*Howard*); *ante*, p. 6. Saint. Louis, Mo. (*Spilochalcis.*)
MONTEZUMA *Cresson;* Transactions American Entomological Society, iv, p. 51. Mexico.
NIGRICORNIS (*Fabricius*); Systema Entomologiæ, suppl., p. 243. North America.
NIGRIFEX *Walker;* Entomological Magazine, ii, p. 22. Georgia.
NIGRIFRONS *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 91 (Tab. v, fig. 9). Bugaba, Panama.
NIGRIVENTRIS *Cameron; ibid.*, p. 96 (Tab. xiv, fig. 14, 14*a*). Chiriqui, Panama.
NIGROMACULATA *Cameron; ibid.*, p. 83 (Tab. iv, fig. 15, *a*, *b*). San Gerónimo.
NIGROPICTA *Cresson;* Proceedings Entomological Society, Philadelphia, iv (1865), p. 94. Cuba.
NORTONII *Cresson;* Transactions American Entomological Society, iv, p. 45. District of Columbia.
OBTUSIVENTRIS *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 93. Presidio, Mexico.
OCTODENTATA *Cameron; ibid.*, p. 82. Presidio, Mexico.
OCTOMACULATA *Cameron; ibid.*, p. 88 (Tab. v, fig. 8). Bugaba, Panama.
ODONTOTÆ (*Howard*); *ante*. p. 7. District of Columbia. (*Spilochalcis.*)
PANAMENSIS *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 90 (Tab. v, fig. 3). Bugaba, Panama.
PALLENS *Cresson;* Proceedings Entomological Society, Philadelphia, iv (1865), p. 96. Cuba.
PETIOLATA *Cresson; ibid.*, p. 97. Cuba.
PETIOLIVENTRIS *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 95. Guatemala.
POMPILIOIDES *Walker;* Notes on Chalcidiæ, Part III, 1871, p. 53. Mexico.
PRATINAS *Walker;* Annals and Magazine of Natural History, 2d ser., 5, p. 130. West Indies.
PULCHRA *Cresson;* Proceedings Entomological Society, Philadelphia, iv (1865), p. 94. Cuba.
PUNCTATA (*Fabricius*); Systema Entomologiæ, ii, p. 196. West Indies; Mexico.
PYLAS *Walker;* The Entomologist (1841), p. 337. Mexico.
QUADRIDENTATA *Cameron;* Biologia Centrali-Americana, Pt. xxvii, Dec., 1883, p. 79. Guatemala.
RUFOFEMORATA *Cresson;* Transactions American Entomological Society, iv, p. 39. Texas.
SANGUINIVENTRIS *Cresson; ibid.*, p. 43. Texas.
SCUTELLARIS *Sichel;* Annales de la Société Entomologique de France, 5th ser., iv. p. 59. Mexico.
SEXDENTATA *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 81. Presidio, Mexico.

SIDE *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 145. Florida.

SUBOBSOLETA *Cresson;* Transactions American Entomological Society, iv, p. 42. Texas.

SUBPUNCTATA *Walker;* Entomological Magazine, ii, p. 25. Saint Vincent.

TENEBROSA *Walker;* Journal of Entomology, i, p. 181. Mexico.

TOLTECA *Cresson;* Transactions American Entomological Society, iv, p. 53. Mexico.

TOLUCA *Cresson; ibid.*, p. 42. Mexico.

TORVINA *Cresson; ibid.*, p. 40. Massachusetts, Connecticut, Illinois, Texas, Missouri, Virginia.

TRANSITIVA *Walker;* Transactions Entomological Society, London, 3d ser., i, p. 371. East Florida.

TRITUBERCULATA *Cameron;* Biologia Centrali-Americana, Pt. xxviii, Febr., 1884, p. 85. Panama; Guatemala.

VIRENS (*Howard*); *ante*, p. 6. Iowa. (*Spilochalcis.*)

Genus CHALCIS Fabr.

AMOENA *Say;* Leconte's Edition of Say's Writings, ii, p. 719. Indiana.

ANNULIPES *Walker;* Entomological Magazine, ii, p. 29. Saint Vincent.

COLORADENSIS *Cresson;* Transactions American Entomological Society, iv, p. 60. Colorado.

COLUMBIANA *Howard*; *ante.*, p. 8. District of Columbia.

COMITATOR *Walker;* Transactions Entomological Society of London, 3d ser., i, p. 350. Mexico.

COMPACTA *Walker;* Journal of Entomology, i, p. 183. Mexico.

DEBELIS *Say;* Leconte's Edition of Say's Writings, ii, p. 720. Indiana.

INCERTA *Cresson;* Proceedings Entomological Society, Philadelphia, iv (1865) p. 101. Cuba.

LASNIERII *Guérin;* Iconographie du Régnè Animal, iii, p. 412; tab. 67, fig. 4. Cuba.

MICROGASTER *Say;* Leconte's Edition of Say's Writings, i, p. 219. Pennsylvania.

MINUTA *Fabricius;* Systema Entomologiæ, ii, p. 195. Georgia.

PEDALIS *Cresson;* Transactions American Entomological Society, iv, p. 60. Texas.

PENDATOR *Walker;* Transactions Entomological Society of London, 3d ser., i, p. 351. San Domingo.

OCTO-NOTATA *Harris;* Catalogue of the Insects of Massachusetts, 2d ed. Massachusetts.

OVATA *Say;* Leconte's Edition of Say's Writings, i, p. 219. Eastern United States.

PUBESCENS *Walker;* Notes on Chalcidiæ, iii, p. 47. Mexico.

RESTITUA *Walker;* Transactions Entomological Society of London, 3d ser., i, p. 351. Jamaica.

ROBUSTA *Cresson;* Proceedings Entomological Society, Philadelphia, iv (1865), p. 101. Cuba; Florida.

TACHINÆ *Howard; ante*, p. 8. New Hampshire.

TEGULARIS *Cresson;* Transactions American Entomological Society, iv, p. 60. Texas.

Genus HALTICHELLA Spinola.

AMERICANA *Howard; ante.* p. 9. Virginia.

CRASSICAUDA (*Sichel*); Annales de la Société Entomologique de France, Ser. 4, iv, p. 377 (Tab. 10, fig. 1). (*Phasgonophora.*)

INSULARIS (*Cresson*); Proceedings Entomological Society of Philadelphia, iv (1865), p. 102. Cuba. (Described as *Phasgonophora.*)

ONATAS (*Walker*); Annales de la Société Entomologique de France, 2d ser., i, p. 146. Florida. (Described as *Hockeria.*)

ORNATICOLLIS *Cameron;* Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 100. Bugaba, Panama.

PERPULCHRA (*Walsh*); Insects Injurious to Vegetation in Illinois, p. 42. Illinois. (Described as *Hockeria.*)
RUFITARSIS (*Cameron*); Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 98 (Tab. v, figs. 10, *a*, *b*, *c*, *d*). Chiriqui, Panama. (*Phasgonophora.*)
RUFIVENTRIS (*Sichel*); Annales de la Société Entomologique de France, ser. 4, v, p. 360 (Tab. 9, fig. 4). (*Phasgonophora.*)
SULCATA (*Westwood*); Griffith's Animal Kingdom, xv, p. 432. Georgia. (Described as *Phasgonophora.*)
XANTICLES (*Walker*); Annales de la Société Entomologique de France, 2d ser., i, p. 147. Florida. (Described as *Hockeria.*)

Genus ACANTHOCHALCIS Cameron.

NIGRICANS *Cameron;* Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 101 (Tab. vi, figs. 14, 14*a*). Sonora, Mexico.

Genus EPITRANUS Walker.

CASTANEUS *Cresson;* Proceedings Entomological Society, Philadelphia, iv (1865), p. 100. Cuba.
FULVESCENS *Walker;* Entomological Magazine, ii, p. 26. Saint Vincent.

Genus NOTASPIS Walker.

FORMICIFORMIS *Walker;* Entomological Magazine, ii, p. 38. Saint Vincent.

Subfamily EUCHARINÆ.

Genus LIRATA Cameron.

LUTEOGASTER *Cameron;* Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 102 (Tab. v, figs. 16, 16*a*). Taboga, Panama.

Genus LOPHYROCERA Cameron.

NIGROMACULATA *Cameron; ibid.*, p. 104 (Tab. 8, figs. 19, *a*, *b*). Nicaragua.
STRAMINEIPES *Cameron; ibid.*, p. 103 (Tab. v, figs. 18, *a*). Panama.

Genus ORASEMA Cameron.

STRAMINEIPES *Cameron; ibid.*, p. 105 (Tab. v, figs. 20, *a*, *b*, *c*; vi, 18, *a*, *b*, *c*, *d*, *e*). Panama.

Subfamily PERILAMPINÆ.

Genus PERILAMPUS Latreille.

ALEXINUS *Walker;* List of the Specimens of Hymenopterous Insects in the Collection of the British Museum. Part I, Chalcidites (1846), appendix, p. 89. Georgia.
CYANEUS *Brullé;* Histoire Naturelle des Insectes, Hyménoptères, 1846, p. 573. Carolina.
ENTELLUS *Walker;* Annals of Natural History, xii, p. 103. Ohio.
HYALINUS *Say;* Leconte's Edition of Say's Writings, i, p. 382. Pennsylvania.
LEPREOS *Walker;* British Museum Catalogues, Chalcidites, i, appendix, p. 89. Georgia.
PLATIGASTER *Say;* Leconte's Edition of Say's Writings, ii, p. 722. Indiana.
TRIANGULARIS *Say; ibid.*, i, p. 381. Indiana.

Subfamily EURYTOMINÆ.

Genus Eurytoma Rossi.

ABATOS *Walker;* Annales de la Société Entomologique de France, ser. 2, i, p. 152. Florida.

ABNORMICORNIS *Walsh;* American Entomologist, ii, p. 299. Illinois.

ALBIPES *Ashmead;* Transactions American Entomological Society, ix (1882), p. xxxi. Florida.

ARGENTATA *Cameron;* Biologia Centrali-Americana, Part xxxi, July, 1884, p. 108. Guatemala.

AURICEPS *Walsh;* American Entomologist, ii, p. 289. Illinois.

AURIFRONS *Cameron;* Biologia Centrali-Americana, Part xxxi, July, 1884, p. 108 (Table V, Figs. 11, *a*, *b*, *c*, *d*, *e*). Guatemala.

BICOLOR *Walsh; ibid.*, p. 298. Illinois.

BOLTERI *Riley;* First Missouri Entomological Report, p. 177. Missouri.

CRETHEIS *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 150. Florida.

DIASTROPHI *Walsh;* American Entomologist, ii, p. 299. Illinois.

FUNEBRIS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1879, p. 196. District of Columbia.

GIGANTEA *Walsh;* American Entomologist, ii, p. 300. Illinois.

HECALE *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 151. Florida.

IPHIS *Walker;* British Museum Catalogues, Chalcidites, i, appendix, p. 85. Florida.

LANULÆ *Fitch;* Fifth Report on the Noxious Insects of New York, p. 37. New York.

ORBICULATA *Say;* Leconte's Edition of Say's Writings, ii, p. 720. Indiana.

PETIOLIVENTRIS *Cameron;* Biologia Centrali-Americana, Part xxxi, July, 1884, p. 108 (Table V, Fig. 12). Panama.

PHYLLOXERÆ *Ashmead;* Transactions American Entomological Society, ix (1882), p. xxx. Florida.

PRUNICOLA *Walsh;* American Entomologist, ii, p. 298. Illinois. Var. *globulicola, ibid.*

PUNCTIVENTRIS *Walsh; ibid.*, p. 299. Illinois.

PHYTHES *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 154. Florida.

STUDIOSA *Say;* Leconte's Edition of Say's Writings, ii, p. 721. Indiana.

SUCCINIPEDIS *Ashmead;* Transactions American Entomological Society, ix (1882), p. xxxi. Florida.

TEREDON *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 153. Florida.

VAGABUNDA *Ashmead;* Canadian Entomologist, xiii (1881), p. 134. Florida.

Genus Decatoma Spinola.

ANTIQUA *Scudder;* Bulletin U. S. Geological Survey, iv, p. 749. Fossil in Green River shales, Colorado.

BATATOIDES *Ashmead;* Canadian Entomologist, xiii, p. 136. Florida.

BICOLOR *Ashmead;* Transactions American Entomological Society, ix (1882), p. xxxii. Florida.

CATESBÆI *Ashmead; ibid.* Florida.

FLAVA *Ashmead;* Canadian Entomologist, xiii, p. 135. Florida.

FOLIATÆ *Ashmead; ibid.*, p. 136. Florida.

HYALIPENNIS *Walsh;* American Entomologist, ii, p. 301. Illinois.

LANÆ *Ashmead;* Canadian Entomologist, xiii, p. 135. Florida.

NIGRICEPS *Walsh;* American Entomologist, ii, p. 300. Illinois. Var. *excrucians, ibid.*

NUBILISTIGMA *Walsh;* American Entomologist, ii, p. 301. Illinois.

ORETILIA *Walker;* Annals of Natural History, xii, p. 46. Saint Vincent.
PHELLOS *Ashmead;* Canadian Entomologist, xiii, p. 136. Florida.
QUERCI *Ashmead;* Canadian Entomologist, xiii, p. 135. Florida.
SIMPLICISTIGMA *Walsh;* American Entomologist, ii, p. 301. Illinois.
VARIANS *Walsh; ibid.*, p. 300. Illinois.

Genus ISOSOMA Walker.

ELYMI *French;* Canadian Entomologist, xiv (1882), p. 10. Illinois.
GRANDE *Riley;* Bulletin of the Brooklyn Entomological Society, vii, p. 111 (December, 1884). Indiana; Ohio.
HORDEI (*Harris*); New England Farmer, ix, No. 1, p. 2 (July 23, 1830). Eastern United States. (Described as *Eurytoma.*)
TRITICI *Riley;* American Naturalist, xvi, p. 248 (March, 1882). Kentucky; Missouri; Illinois; Indiana; Washington Territory.
VITIS *Saunders;* Canadian Entomologist, ii, p. 26 (November, 1869). Canada.

Genus BEPHRATA Cameron.

RUFICOLLIS *Cameron;* Biologia Centrali-Americana, Part xxxi, July, 1884, p. 109 (Table V, Figs. 13, *a*). Panama.

Subfamily AXIMINÆ.

Genus HONTALIA Cameron.

CÆRULEA *Cameron; ibid.*, p. 113 (Table VI, Figs. 1, *a*). Nicaragua.
RUFICORNIS *Cameron; ibid.*, p. 113 (Table VI, Figs. 2, *a*, *b*, *c*). Panama.

Subfamily TORYMINÆ.

Genus DIOMORUS Walker.

MAYRI *Cameron; ibid.*, p. 106 (Table iv, Figs. 17, *a*, *b*). Guatemala.
RUFIPES, *Cameron; ibid.*, p. 105. Guatemala.

Genus SYNTOMASPIS Förster.

MACULIPENNIS *Cameron; ibid.*, p. 107. Sonora, Mexico.

Genus MEGASTIGMUS Dalman.

PINUS *Parfitt;* The Zoologist, 15, p. 5543. California.

Genus CALLIMOME Spinola.

ADVENA *Osten-Sacken;* Transactions American Entomological Society, iii, (1870–'71), p. 59. District of Columbia.
ÆA *Walker;* Annals of Natural History, xii, p. 104. New York.
ÆNEA *Ashmead;* Transactions American Entomological Society, ix (1882), p. xxxiii. Florida.
BREVICAUDA *Osten-Sacken; ibid.*, iii, p. 62. District of Columbia. (?)
BREVISSIMICAUDA *Ashmead; ibid.*, ix, p. xxxiii. Florida.
CÆRULEA *Ashmead; ibid.* Florida.
CECIDOMYIÆ *Walker;* Annals of Natural History, 14, p. 15. Hudson's Bay.
CHRYSOCHLORA *Osten-Sacken;* Transactions American Entomological Society, iii, p. 63. New England.
DURA *Osten-Sacken; ibid.*, p. 59. *Nul. loc.*
ELEGANTISSIMA *Ashmead; ibid.*, ix, p. xxxiv. Florida.

FLAVICOXA *Osten-Sacken; ibid.*, iii, p. 61. *Nul. loc.*

LISSUS *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 150. Florida.

MAGNIFICA *Osten-Sacken;* Transactions American Entomological Society, iii, p. 62. *Nul. loc.*

RECEMARIÆ *Ashmead; ibid.*, ix, p. xxxiii. Florida.

SOLITARIA *Osten-Sacken; ibid.*, iii, p. 64. *Nul. loc.*

SPLENDIDUS *Barnstone* MSS., *Walker;* Annals of Natural History, 14, p. 14. Hudson's Bay.

THEON *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 149. Florida.

TUBICOLA *Osten-Sacken;* Transactions American Entomological Society, iii, p. 60. District of Columbia.

VIRENTIS *Ashmead; ibid.*, ix, p. xxxiv. Florida.

Genus TORYMUS Dalman.

AMETHYSTINUS *Harris;* Catalogue of the Insects of Massachusetts, 2d ed. Massachusetts.

AZALEÆ *Harris; ibid.* Massachusetts.

OCHREATUS *Say;* Leconte's Edition of Say's Writings, ii, p. 723. Indiana.

PAVIDUS *Say; ibid.* Indiana.

SEMIAURATUS *Harris;* Catalogue of the Insects of Massachusetts, 2d ed.

Genus ORMYRUS Westwood.

LABOTUS *Walker;* Annales de la Société Entomologique de France, ser. 2, i, p. 148. Florida.

Genus IDARNES Walker.*

CARME *Walker;* Annals of Natural History, 12, p. 47. Saint Vincent.

Subfamily EUPELMINÆ.

Genus EUPELMUS Dalman.

ALBISPINA *Cameron;* Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 120. Panama.

ALLYNII (*French*); Canadian Entomologist, xiv (1882), p. 9. Illinois. (Described as *Isosoma.*)

BIMACULATUS *Cameron;* Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 120. Panama.

BREVICORNIS *Cameron; ibid.*, p. 117. Panama.

BUCCULATRICIS *Howard* MSS.; *Brunn*, in Second Report Department Entomology, Cornell University Experiment Station (1883), p. 161. New York.

CINGULATUS *Cameron;* Biologia Centrali-Americana, Pt. xxxii, Aug., 1884, p. 122. Guatemala; Panama.

COMPRESSICORNIS *Cameron; ibid.*, Pt. xxxi, July, 1884, p. 115 (Tab. vi, fig. 12). Panama.

CYNIPIDIS *Ashmead;* Canadian Entomologist xiv, p. 37. Florida.

EPICASTE *Walker;* Annals of Natural History, 20, p. 20. North America.

ERYTHROTHORAX *Cameron;* Biologia Centrali-Americana, Pt. xxxii, Aug., 1884, p. 121. Panama.

FASCIIVENTRIS *Cameron; ibid.*, p. 123. Panama.

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*I am not familiar with this genus, and place it only on the authority of a suggestion in Walker's notes on the *Agonidæ*. L. O. H.

FLAVIPES *Cameron; ibid.*, p. 122. Guatemala.
FLORIDANUS *Howard;* Canadian Entomologist xii (1880), p. 209. Florida.
FONTEIA *Walker;* Annals of Natural History, 20, p. 19. North America.
GENICULATUS *Cameron;* Biologia Centrali-Americana, Pt. xxxi, July, 1884, p. 119. Panama.
GIGAS *Cameron; ibid.*, p. 116 (Tab. vi, figs. 9, *a*). Panama.
GRACILIS *Cameron; ibid.*, Pt. xxxii, Aug., 1884, p. 121. Guatemala.
HYALINIPENNIS *Cameron; ibid.*, p. 121. Guatemala.
LAMACHUS *Walker; ibid.*, p. 20. North America.
MIRABILIS (*Walsh*); American Entomologist ii, p. 369. Illinois. (Described as *Antigaster*, nov. gen.)
PETIOLARIS *Cameron;* Biologia Centrali-Americana, Pt. xxxii, Aug., 1884, p. 123. Guatemala.
REDUVII *Howard;* Canadian Entomologist xii, p. 207. District of Columbia.
ROSÆ *Ashmead; ibid.*, xiv, p. 36. Florida.
TESTACEUS *Cameron;* Biologia Centrali-Americana, Pt. xxx, July, 1884, p. 117 (Tab. vi, figs. 10, *a*). Panama.
TESTACEICORNIS *Cameron; ibid.*, p. 119. Panama.

Genus BRASEMA Cameron.

BREVISPINA *Cameron; ibid.*, Pt. xxxii, Aug., 1884, p. 124. Guatemala.

Genus ASEIRBA Cameron.

CAUDATA *Cameron; ibid.*, p. 128 (Tab. vi, fig. 13). *Nul. loc.*

Genus LUTUES Cameron.

CRASSICORNIS *Cameron; ibid.*, p. 126 (Tab. vi, fig. 15). Panama.
DROMEDARIUS *Cameron; ibid.*, p. 126. Panama.
LONGIVENTRIS *Cameron; ibid.*, p. 127. Panama.
ORNATICOLLIS *Cameron; ibid.*, p. 125 (Tab. vi, Figs. 16, *a*). Panama.

Genus METAPELMA Westwood.

SPECTABILIS *Westwood;* Proceedings of the Zoological Society, 1835, p. 69. Georgia.

Subfamily ENCYRTINÆ.

Genus RHOPUS Förster.

COCCOIS (*E. A. Smith*); North American Entomologist, i., p. (Described as *Acerophagus*, nov. gen.)

Genus APHYCUS Mayr.

ANNULIPES (*Ashmead*); Canadian Entomologist, xiv, p. 37. Florida. (Described as a *Coccophagus.*)
BRUNNEUS *Howard; ante*, p. 17. New Jersey.
CEROPLASTIS *Howard; ante*, p. 18. New Mexico.
ERUPTOR *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 364. Florida; Virginia.
FLAVUS *Howard; ibid.*, p. 365. Florida.
MACULIPES *Howard; ante*, p. 18. South Carolina.
PULVINARIÆ *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 365. Iowa.

Genus BLASTOTHRIX Mayr.

ADJUTABILIS *Howard; ibid.*, p. 365. Florida; Virginia.
INCERTA *Howard; ibid.*, p. 366. Florida.
LONGIPENNIS *Howard; ibid.*, p. 366. District of Columbia.

Genus ENCYRTUS Dalman.

ARTACEÆ *Howard; ibid.*, p. 252. Florida.
BOLUS *Walker;* Annals of Natural History, 14, p. 17. Hudson's Bay.
BUCCULATRICIS *Howard;* Lintner's First Report as State Entomologist of New York (1882), p. 160. New York; Missouri; District of Columbia.
CECIDOMYIÆ *Howard; ante*, p. 16. Virginia.
ENSIFER *Howard; ante*, p. 13. Florida.
FLACCUS *Walker;* Annals of Natural History, 20, p. 21. North America.
FLAVUS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 367. California.
FUSCICORNIS *Howard; ante*, p. 13. Maryland.
GARGARIS *Walker;* Annals of Natural History, 12, p. 47. Saint Vincent.
GASTRON *Walker; ibid.*, 20, p. 21. North America.
HYETTUS *Walker; ibid.*, 17, p. 181. Saint Vincent.
INQUISITOR *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 367. Florida.
MONTINUS *Packard;* Geology of New Hampshire, vol. i, Final Rept., chap. xii, p. 347. New Hampshire.
PACHYPSYLLÆ *Howard; ante*, p. 15. Maryland.
PUNCTICEPS *Howard; ante*, p. 14. Virginia.
REATE *Walker;* Annals of Natural History, 20, p. 22. North America.
SOLUS *Howard; ante*, p. 15. Florida.
SUBLESTUS *Howard; ante*, p. 12. Florida.
TRIOZIPHAGUS *Howard; ante*, p. 14. District of Columbia.
TURNI *Packard;* Proceedings Boston Society of Natural History, xxi, p. 32. *Nul. loc.*
VECTIUS *Walker;* Annals of Natural History, 20, p. 21. North America.

Genus PSILOPHRYS Mayr.

HYALINIPENNIS *Howard; ante*, p. 21. Missouri.

Genus LEPTOMASTIX Förster.

DACTYLOPII *Howard; ante*, p. 23. District of Columbia.

Genus COPIDOSOMA Ratzeburg.

CELÆNÆ *Howard; ante*, p. 11. Missouri.
GELECHIÆ *Howard; ante*, p. 10. District of Columbia; New Hampshire; Missouri.
INTERMEDIUM *Howard; ante*, p. 12. New Jersey.
VAGUM *Howard; ante*, p. 11. Missouri.

Genus COMYS Förster.

BICOLOR *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 362. District of Columbia.
FUSCA *Howard; ibid.*, p. 363. Alabama.

Genus CHILONEURUS Westwood.

ALBICORNIS *Howard; ibid.*, p. 363. District of Columbia; Iowa; South Carolina.
DUBIUS *Howard; ante*, p. 17. Wisconsin.
DACTYLOPII *Howard; ante*, p. 17. District of Columbia.

Genus HOMALOTYLUS Mayr.

OBSCURUS *Howard; ante*, p. 22. Florida.

Genus BOTHRIOTHORAX Ratzeburg.

PECULIARIS *Howard; ante*, p. 20. Virginia.
VIRGINIENSIS *Howard; ante*, p. 20. Virginia.

Subfamily APHELININÆ.

Genus COCCOPHAGUS Westwood.

ATER *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 359. New York.

COGNATUS *Howard; ibid.*, p. 359. District of Columbia.

FLAVIFRONS *Howard; ante*, p. 25. Florida.

FRATERNUS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 359. District of Columbia.

FUSCIPES *Howard; ibid.*, p. 359. Florida.

IMMACULATUS *Howard; ibid.*, p. 358. District of Columbia.

KOEBELEI *Howard; ante*, p. 25. Florida.

LECANII (*Fitch*); Fifth Report as State Entomologist of New York, p. 25. New York; Illinois; District of Columbia; California. (Described as *Platygaster*.)

VARICORNIS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 360. District of Columbia.

VIVIDUS *Howard; ante*, p. 24. Florida.

Genus APHELINUS Dalman.

ABNORMIS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 355. District of Columbia.

ASPIDIOTICOLA *Ashmead;* Canadian Entomologist xi (1879), p. 159. Florida. (Evidently a Mymarid.)

DIASPIDIS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 355. Florida; California.

FUSCIPENNIS *Howard; ibid.*, p. 356. Florida; California; District of Columbia.

MALI (*Haldeman*); Proceedings Boston Society of Natural History, vi, p. 403. Pennsylvania; Illinois; Missouri; District of Columbia. (Described under *Eriophilus*, nov. gen.)

MYTILASPIDIS *Le Baron*; American Entomologist, ii, p. 360. Illinois; Missouri; New York; California; District of Columbia.

PULCHELLUS *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 356. District of Columbia.

Subfamily PIRENINÆ.

Genus MACROGLENES Westwood.

QUERCI-GLOBULI *Fitch;* Fifth Report as State Entomologist of New York, p. 32. New York.

QUERCI-PISI *Fitch; ibid.*, p. 39. New York.

Genus TOMOCERA Howard.

CALIFORNICA *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 368. California.

Subfamily SPALANGIINÆ.

Genus SPALANGIUS Latreille.

CHONTALENSIS *Cameron;* Biologia Centrali-Americana, Part xxxi, July, 1884, p. 110 (Table v, Figs. 14, *a*). Nicaraugua.

POLITUS *Say;* Leconte's Edition of Say's Writings, i, p. 382. Virginia.

QUERCI-LANÆ *Fitch;* Fifth Report as State Entomologist of New York, p. 36. New York.

SYRPHI *Ashmead;* Canadian Entomologist, xiii, p. 171. Florida.

Genus PARALÆSTHESIA Cameron.

MANDIBULARIS *Cameron;* Biologia Centrali-Americana, Part xxxi, July, 1884, p. 111 (Table v, Figs. 15, *a, b, c, d*). Panama.

Subfamily PTEROMALINÆ.

Genus LAMPROTATUS Westwood.

CYRNUS *Walker;* Annales de la Société Entomologique de France, 2d ser., i, 157. Florida.

DILÆUS *Walker;* Annals of Natural History, 14, p. 16. Hudson's Bay.

HABIS *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 155. Florida.

SALEMUS *Walker; ibid.*, p. 156. Florida.

TRYPHENUS *Walker; ibid.*, p. 158. Florida.

Genus MICROMELUS Walker.

CYRENE *Walker; ibid.*, p. 154. Florida.

Genus GLYPHE Walker.

VIRIDASCENS *Walsh;* Insects Injurious to Vegetation in Illinois, p. 38, fig. 9. Illinois.

Genus EPISTENIA Westwood.

CŒRULATA *Westwood;* Griffith's Animal Kingdom, 15, p. 432. Georgia.

Genus LELAPS Halliday.

PULCHRICORNIS *Halliday;* Transactions Entomological Society of London, vol. iii, p. 300. Saint Vincent.

Genus PACHYNEURON Walker.

ALBUTIUS *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 158. Florida.

ALTISCUTA *Howard*, MSS., *Cook, A. J.;* Notes on Injurious Insects; Entomological Laboratory, Michigan Agricultural College, August, 1884, p. 13. Michigan.

Genus CHEIROPACHYS Westwood.

NIGRO-CYANEUS *Norton;* Transactions American Entomological Society, ii, p. 327. Connecticut.

Genus SEMIOTELLUS Westwood.

CHALCIDIPHAGUS *Walsh;* American Entomologist, ii, p. 368. Canada; Virginia.

CLISIOCAMPÆ *Fitch;* Second Report as State Entomologist of New York, p. 200. New York. (Described as *Cleonymus.*)

DESTRUCTOR (*Say*); Leconte's Edition of Say's Writings, ii, p. 6. Northern United States. (Described as *Ceraphron.*)

Genus STICTONOTUS Förster.

ISOSOMATIS *Riley;* Annual Report U. S. Commissioner of Agriculture, 1881–'82, p. 186. Tennessee.

Genus EUTELUS Walker.

SCYMNÆ *Shimer;* Transactions American Entomological Society, ii, p. 385. Illinois.

Genus PTEROMALUS Swederus.

ARCTIÆ *Harris;* Catalogue of the Insects of Massachusetts, 2d ed.
CALANDRÆ *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 273. Texas.
CASSOTIS *Walker;* Annals of Natural History, 19, p. 393. North America.
CLISIOCAMPÆ *Harris;* Catalogue of the Insects of Massachusetts, 2d ed.
CRATYLUS *Walker;* Annals of Natural History, 19, p. 392. North America.
DAMO *Walker; ibid.*, p. 395. North America.
DIPSUS *Walker; ibid.*, p. 394. North America.
DORYSSUS *Walker; ibid.*, p. 395. North America.
DYMNUS *Walker; ibid.*, p. 397. North America.
EPICLES *Walker; ibid.*, p. 394. North America.
ERYX *Walker; ibid.*, p. 397. North America.
EURYPON *Walker; ibid.*, p. 398. North America.
EUTHYMUS *Walker; ibid.*, p. 393. North America.
GELECHIÆ *Webster;* Twelfth Report of the State Entomologist of Illinois (1882), p. 151. Illinois.
HELICE *Walker;* Annals of Natural History, 12, p. 46. Saint Vincent.
HERMEAS *Walker; ibid.*, 19, p. 394. North America.
HYBREAS *Walker; ibid.*, p. 397. North America.
LAUSUS *Walker; ibid.*, p. 392. North America.
LEPTURUS *Harris;* Catalogue of the Insects of Massachusetts, 2d ed.
OBESUS *Harris; ibid.*
ŒAX *Walker;* Annals of Natural History, 19, p. 395. North America.
ONERATE *Fitch;* Fifth Report as State Entomologist of New York, p. 32. New York.
ORONTAS *Walker;* Annals of Natural History, 19, p. 396. North America.
QUADRI-MACULATÆ *Ashmead;* Canadian Entomologist, xiii, p. 171. Florida.
QUERCI-PILLULÆ *Fitch;* Fifth Report, p. 39. New York.
TABACUM *Fitch;* Ninth Report, p. 792. New York.
TIMÆA *Walker;* Annals of Natural History, 19, p. 396. North America.
VANNESSÆ *Harris;* Catalogue of the Insects of Massachusetts, 2d ed.
VERDITER *Norton;* Transactions American Entomological Society, ii, p. 327. *Nul. loc.*

Genus METOPON Walker.

DEIPHON *Walker;* Annales de la Société Entomologique de France, 2d ser., i, p. 161. Florida.

Subfamily ELACHISTINÆ.

Genus EUPLECTRUS Westwood.

BICOLOR (*Swederus*); Kongl. Vet. Ac. Handl., 1795, 204, 2. Saint Vincent. (Described as *Pteromalus*.)
CATOCALÆ *Howard; ante*, p. 27. Missouri; Maryland.
COMSTOCKII *Howard;* Canadian Entomologist, xii (1880), p. 159. Alabama.
FRONTALIS *Howard; ante*, p. 27. Virginia.
FURNIUS *Walker;* Annals of Natural History, 12, p. 48. Saint Vincent.
LEUCOTROPHIS *Howard; ante*, p. 26. Florida.
PLATYHYPENÆ *Howard; ante*, p. 26. District of Columbia.

Genus STENOMESIUS (?) Westwood.

APHIDICOLA *Ashmead;* Orange Insects (Jacksonville, 1880), p. 67. Florida.

Genus ELACHISTUS Spinola.

CACŒCIÆ *Howard; ante*, p. 28. Missouri.
COXALIS *Howard; ante*, p. 28. District of Columbia.
LEVANA *Walker;* Annals of Natural History, 20, p. 27. North America.
PROTEOTERATIS *Howard; ante*, p. 27. Missouri.

Genus CIRROSPILUS Westwood.

EUNAPIUS *Walker;* Annals of Natural History, 20, p. 27. North America.
FLAVICINCTUS *Riley;* Lintner's First Report as State Entomologist of New York (1882), p. 159. Missouri.

Subfamily ELASMINÆ.

Genus ELASMUS Westwood.

ALBICOXA *Howard; ante*, p. 30. Missouri.
NIGRIPES *Howard; ante*, p. 30. Missouri.
PULLATUS *Howard; ante*, p. 30. Missouri.
TISCHERIÆ *Howard; ante*, p. 30. District of Columbia.
VARIUS *Howard; ante*, p. 29. Missouri.

Subfamily EULOPHINÆ.

Genus SYMPIEZUS Förster.

LITHOCOLLETIDIS *Howard* MSS.; *Brunn* in Second Report Department of Entomology, Cornell University Experiment Station (1883), p. 150. New York.

Genus EULOPHUS Geoffrey.

BASALIS *Say;* Leconte's Edition of Say's Writings, ii, p. 721. Indiana.
CALAVIUS *Walker;* Annals of Natural History, 20, p. 24. North America.
CYRIADES *Walker; ibid.*, p. 25. North America.
DICLADUS *Say;* Leconte's Edition of Say's Writings, ii, p. 721. Indiana.
GORBRYAS *Walker;* Annals of Natural History, 20, p. 26. North America.
HIRCINUS *Say;* Leconte's Edition of Say's Writings, ii, 722. Indiana.
IPINOË *Walker;* Annals of Natural History, 20, p. 25. North America.
MINIS *Walker; ibid.* North America.
MINUTUS *Howard* MSS.; *Brunn* in Second Report Department of Entomology, Cornell University Experiment Station (1883), p. 150. New York.
MINYAS *Walker;* Annals of Natural History, 20, p. 25. North America.
SEMIDIÆ *Packard;* Report Geology New Hampshire, i (1874), p. 347, fig. 46. New Hampshire.
SAUNDERSII *Packard;* Proceedings Boston Society of Natural History, vol. xxi (1880), p. 34. Canada.
THECLÆ *Packard; ibid. Nul. loc.*

Genus ANTHOPHORABIA Newport.

MEGACHILIS *Packard;* Proceedings Essex Institute, iv., p. 13. *Nul. loc.*

Subfamily ENTEDONINÆ.

Genus ENTEDON Dalman.

ANTIOPÆ *Packard;* Proceedings Boston Society of Natural History, xxi (1880), p. 36. *Nul. loc.*

DIASTATÆ *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 246. District of Columbia.

HERILLUS *Walker;* Annals of Natural History, 20, p. 23. North America.

IMBRASUS *Walker; ibid.* North America.

SARDUS *Walker; ibid.* North America.

Genus DEROSTENUS Westwood.

TISCHERIÆ (*Howard* MSS.); *Brunn* in Second Report Department of Entomology, Cornell University Experiment Station (1883), p. 157. (There mentioned as an *Astichus.*)

Subfamily TETRASTICHINÆ.

Genus GYROLASIA Förster.

FLAVIMEDIA *Howard;* Annual Report U. S. Commissioner of Agriculture, 1880, p. 369. California.

Genus TETRASTICHUS Halliday.

EPIDIUS *Walker;* Annals of Natural History, 20, p. 28. North America.

ESURUS (*Riley*); Canadian Entomologist, xi (1879), p. 162. Southern United States. (Described as a *Cirrospilus.*)

GALA *Walker;* Annals of Natural History, 20, p. 28. North America.

GRANULATUS *Walker; ibid.*, 14, p. 17. Hudson's Bay.

LAEMON *Walker; ibid.*, 20, p. 28. North America.

Subfamily TRICHOGRAMMINÆ.

Genus TRICHOGRAMMA Westwood.

? FRATERNA *Fitch;* Second New York Report, p. 217. New York.

FLAVUS *Ashmead;* Orange Insects (1880), p. 33, pl. i. Florida.

MINUTA *Riley;* Third Missouri Entomological Report, p. 158. Missouri.

MINUTISSIMUM *Packard;* Proceedings Boston Society of Natural History, xxi (1880), p. 37. *Nul. loc.*

? ORGYIÆ *Fitch;* Second New York Report, p. 216. New York.

PRETIOSA *Riley;* Canadian Entomologist, xi (1879), p. 161. Southern United States.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 6.
(SECOND EDITION.)

THE IMPORTED

ELM LEAF-BEETLE.

ITS HABITS AND NATURAL HISTORY,

AND

MEANS OF COUNTERACTING ITS INJURIES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1891.

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., October 19, 1891.

SIR: I have the honor to submit for publication a second edition of Bulletin No. 6 of this Division, on the Imported Elm Leaf-beetle, as there is constant demand from correspondents for information on the subject. The original edition was published in 1885 and has long since been exhausted. The substance of the bulletin was subsequently reprinted in Bulletin No. 10 of this Division, which is, however, more comprehensive than is necessary for specific distribution to persons interested in this insect alone. The present edition is in the main a reprint, but a few additional facts are added in an appendix.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

THE IMPORTED ELM LEAF-BEETLE.

(*Galeruca xanthomelæna** Schrank.)

Order COLEOPTERA; family CHRYSOMELIDÆ.

The depredations of this pest have now become widely extended throughout the Northeastern States, rendering unsightly and almost worthless those most valuable shade trees of our cities—the elms. As its injuries are so far unknown in the Mississippi Valley, the blighted appearance of the elms on the Department grounds in midsummer, and especially of the European varieties, at once attracted our attention when we first came to Washington, and a series of experiments was begun with a view of checking the ravages of the insect. The excellent opportunities thus offered for experiment and study have since been improved, and, with some prefatory passages in relation to the history and habits of the beetle, we will give the practical results reached.

AN IMPORTATION FROM EUROPE.

This beetle has done great mischief in the Old World, especially in Germany and France, and it is very important that the public know the best method of coping with it here. According to Glover, it was imported as early as 1837. Its distribution was formerly confined to limited areas near the coast, and its earlier attacks were notably about Baltimore and New Jersey.

HABITS AND NATURAL HISTORY.

The general characteristics of this insect have been pretty well studied abroad. Mr. E. Heeger† has given an excellent account of its life history, with a detailed description of the larva, and figures illustrating larva and pupa and anatomical details. More recently M. Maurice Girard‡ has given a rather poor wood-cut illustration of the insect and its work, with the leading facts concerning its nomenclature and nat-

* This is the *Galeruca cratægi* Forst., and *G. calmariensis* Fabr. In Crotch's Check List it appears as *Galerucella xanthomelæna*.

† Seventeenth contribution to the natural history of insects. Sitzungsberichte der. kais. Ac. Wiss., Wien, 1858, vol. 29, p. 100–120, 6 pl.

‡ Note sur la Galéruque de l'orme. Bull. d'Insectologie Agricole, 1878, III, pp. 113–116.

ural history as observed in Europe. Biological notes on the insect have also been given by Leinweber* and Kollar.†

In our country the life history of the insect and its injury have been referred to by Harris, Fitch, Morris, Walsh, and ourselves, while the agricultural papers contain numerous references to the injury inflicted by the insect. The perfect beetle has often been described in systematic works on Coleoptera.

For these reasons we deem it unnecessary to enter here into a detailed description of the beetle and its earlier stages, but content ourselves with pointing out the more obvious characters, alluding to such facts of the life history as are necessary to a full understanding of the nature of the remedies to be applied for this pest.

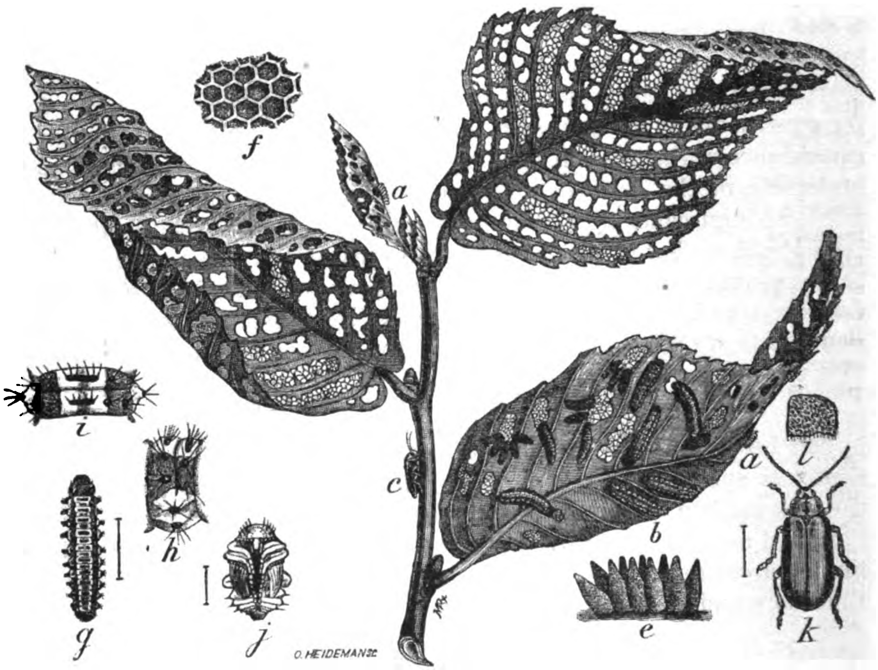

FIG. 1.—*Galeruca xanthomelæna: a*, eggs; *b*, larvæ; *c*, adults; *e*, eggs (enlarged); *f*, sculpture of egg; *g*, larva (enlarged); *h*, side view of greatly enlarged segment of larva; *i*, dorsal view of same; *j*, pupa (enlarged); *l*, portion of elytron of beetle (greatly enlarged).—After Riley.

The eggs are deposited in an upright position upon the under side of the leaves (Fig. 1 *a*), always in a group, consisting generally of two, rarely three, more or less irregular rows. The individual eggs are close together in each group (Fig. 1 *e*, magnified), and so firmly fastened to the leaf that they can only be detached with great care without breaking the thin and brittle shell. The number of eggs in each group varies from four or five to twenty or more. Very rarely only three eggs are seen in one

* Verhandlungen zool. bot. Ges., Wien, 1856, VI; Sitzb., pp. 74–75.
† *Op. cit.*, 1858, VIII; Abh., pp. 29–30.

group, but we never found less than that number. The egg itself is oblong oval, obtusely, but not abruptly, pointed at tip, of straw-yellow color, its surface being opaque and beautifully and evenly reticulated, each mesh forming a regular hexagon, as shown, highly magnified, in Fig. 1 *f*. The form of the eggs is not quite constant, some of them, especially those in the middle of a large group, being much narrower than others. The duration of the egg state is about one week.

The general shape of the larva is very elongate, almost cylindrical, and distinctly tapering posteriorly in the early stages, but less convex and of nearly equal width when mature. The general color of the young larva is yellowish-black, with the black markings comparatively larger and more conspicuous, and with the hairs arising from these markings much longer and stiffer than in the full-grown larva. With each consecutive molt the yellow color becomes more marked, the black markings of less extent and of less intense color, and the hairs much shorter, sparser, and lighter in color. A nearly full-grown larva is represented in Fig. 1 *g*, and in this the yellow color occupies a wide dorsal stripe and a lateral stripe each side. The head (excepting the mouth parts and anterior margin of the front), the legs (excepting a ring around the trochanters), and the posterior portion of the anal segment are always black. The first thoracic segment has two large black spots on the disk, of varying extent, and often confluent. The following segments (excepting the anal segment) are dorsally divided by a shallow transverse impression into two halves, and the black markings on these halves are arranged as follows: Two transverse dorsal markings, usually confluent, as shown in our figure; two round and sublateral spots; the tips of the lateral tubercles are also black. The abdominal joints of the ventral surface have each a transverse medial mark, and two round sublateral spots of black color. Stigmata visible as small umbilicate spots between outer sublateral series of dorsal markings and lateral tubercles. The yellow parts of the upper side are opaque, but those of the underside shining. The black markings are polished, piliferous, and raised above the remaining portions of the body.

The larvæ are destructive to the foliage from the month of May until August. They have about two weeks of active life between the egg and pupa states. During this time they prey upon the leaves, which become skeletonized, leaving the venation and commonly a certain portion of the flesh of the leaf, which becomes rust brown. They undergo four molts, respectively observed at Washington on July 15 (at hatching), 20, 23, and 29 (pupation). When full grown they descend to the ground and change to pupæ under whatever shelter is near to the base of the tree.

The pupa is of brighter color than the larva, oval in shape, and strongly convex dorsally. It is sparsely covered with moderately long but very conspicuous black bristles, irregularly arranged on head and thorax, but in a transverse row on each following segment. The pupa state lasts from about six to ten days.

The perfect beetle (Fig. 1 *c*, natural size; *k*, magnified) resembles somewhat in appearance the well-known striped Cucumber-beetle (*Diabrotica vittata*), but is at once distinguished by the elytra not being striate punctate, but simply rugose, the sculpture under high magnifying being represented in Fig. 1 *l*. The color of the upper side is pale yellow or yellowish-brown, with the following parts black: On the head a frontal (often wanting) and a vertical spot; three spots on the thorax; on the elytra a narrow stripe along the suture, a short, often indistinct scutellar stria each side,

and a wider humeral stripe not reaching the tip. Under side black, pro- and meso-sternum and legs yellow, femora with a black apical spot. Upper and under side covered with very fine, short, silky hairs. In newly-hatched individuals the black markings have a greenish tint; the humeral stripe varies in extent.

The beetle assists the larva in its destructive work, but, as usual in such cases, the damage done by the perfect insect is small when compared with that done by the larva. There are two or more annual generations of the insect, judging from the facts that have been collected, the number varying doubtless with the latitude. In the month of September the beetles prepare for hibernation, seeking shelter in hollow trees, in the ground, under old leaves, etc., and remain dormant until the following spring.

REMEDIES.

M. Girard says:

There is no other means of destruction than to jar the branches over cloths to collect the larvæ and adults which fall. It is also possible when they are on the ground to distribute on them boiling water or steam, or even quicklime or solution of sulpho-carbonate of potassium.

In our own country much more has been accomplished toward practically combating this insect.

In the U. S. Agricultural Report of 1867, Glover suggested the use of oil and tar gutters and other barriers surrounding the base or the body of the tree, devices similar to those used against the Canker Worm and Codling Moth. He then and afterward (1870) recommended "to place around each tree small, tight, square boxes or frames, a foot or 18 inches in height, sunk in the earth; the ground within the inclosure to be covered with cement, and the top edge of each frame to be covered with broad, projecting pieces of tin like the eaves of a house or the letter T, or painted with some adhesive or repellant substance, as tar, etc. The larvæ descending the tree, being unable to climb over the inclosure, would change into helpless pupæ within the box, where they could daily be destroyed by thousands. Those hiding within the crevices of the bark of the trunk could easily be syringed from their hiding places." (U. S. Agricultural Report, 1870, pp. 73, 74.) These boxes were carefully tested at this Department, and they worked as described. While coal tar and other adhesives were recommended, we have found scalding-hot water most convenient for destroying the insects that accumulate in the inclosure or upon the ground elsewhere. Where branches are low and droop near the ground some of the larvæ descend the wrong way and fall off, but shade trees should not be allowed to grow in this low, drooping manner, and under all ordinary circumstances, where the branches are not severely jarred to encourage the insects to drop, the larvæ will descend by the trunk and become captured in the devices here noticed.

Mr. Glover regarded the pupa state as the most favorable in which to kill the insect, as it can then be easily crushed or scalded. Concerning the tobacco treatment, he adds that "syringing the trees with strong

tobacco water has been tried with some good effect, but the larvæ not touched by the fluid are merely knocked down by the concussion, and, if nearly ready to change into pupæ, effect their transformation where they fall."

In this connection we can not do better than quote what we published in 1880* in reply to certain statements by Dr. J. L. LeConte, as follows:

Anent *Galeruca xanthomelæna*, which is becoming more destructive each successive year to the shade elms in our northern towns, a correspondent mentions the following facts:

1. The trees are not all attacked at the same time, but the insect seems to break out from a center, gradually destroying the more remote trees, so that isolated trees remain comparatively free.

2. After applying a band (saturated with fish oil, petroleum, etc.) to some trees which were about half denuded, found hundreds of the worms stopped both in ascending and descending the trees.

He also propounded the following query:

3. Do the beetles hibernate in the ground, so that they can be poisoned, or are they perpetuated only by the eggs on the trees?

Allow me to add the following subjects for investigation as necessary to the devising of proper remedies against this foreign invader:

4. How soon do the insects appear in the spring; how rapidly do they propagate; and what time is passed in each stage of development?

5. Are the larvæ and beetles eaten by insectivorous birds; or are they protected by offensive secretions, as is the case with *Doryphora 10-lineata*, *Orgyia leucostigma*, and several other noxious insects?

6. What proportion of the brood hibernates, and in what stage, pupa or perfect insect, and where?

If the materials for furnishing answers to these questions are not yet within your reach, will you kindly direct the attention of some of your trusty observers to the subject, so that persons interested in the preservation of the shade trees which are so justly esteemed may be properly instructed as to the measures to be adopted during the next summer.

Very truly yours,

J. L. LeConte,
Philadelphia, Pa.

The above inquiries were received from our esteemed correspondent some time since, and we employ them as a ready means of giving our experience with the beetle.

For the benefit of the general reader it may be remarked that the natural history of this Elm Leaf-beetle is quite similar to that of the well-known Colorado Potato-beetle and of the Grape-vine Flea-beetle. The only deviation in the Elm Leaf-beetle is in the mode of pupation, which rarely takes place in the ground, unless this be very friable, but at the base of the tree or under any shelter that may present itself near the trees, such as old leaves, grass, etc.

(1) The phenomenon here described is doubtless due to the gradual increase in spring from one or more females.

(3 and 6) Like most, if not all, *Chrysomelidæ*, the Elm Leaf-beetle hibernates in the perfect state. As places suitable for hibernation abound, any attempt to successfully fight this pest in winter time, with a view of preventing its ravages the subsequent season, will prove fruitless. A large proportion of the hibernating beetles doubtless perish, since the insect is comparatively scarce in the earlier part of the season.

(4 and 5) The beetles fly as soon as spring opens, and we have observed the first larvæ early in May, in Washington, D. C., or sometime after the elm leaves are fully developed. The ravages of the insect begin to be apparent with the second generation of larvæ, which appear in June.

*American Entomologist, December, 1890, v. 3, p. 291.

In 1878 we made many notes and experiments on the species, and the development of the third and most injurious generation occupied about one month. The numerous pupæ which in the latter part of August were to be found under the trees were mostly destroyed that year, partly by continuous wet weather prevailing at the time, partly by the many enemies of the insect. Among these there are *Platynus punctiformis* and *Quedius molochinus*, which feed on the full-grown larvæ when these retire for pupation, and also on the pupæ. The larva of a *Chrysopa* (probably *C. rufilabris*) feeds upon the eggs of the *Galeruca*, *Reduvius novenarius* sucks both beetles and larvæ on the leaves, while *Mantis carolina* preys upon the beetle. Of the numerous other insects found among the pupæ under the trees, *e. g.*, *Tachyporus jocosus*, sundry spiders, myriapods, etc., several are doubtless enemies of the *Galeruca*, though we have as yet no proof of the fact. Many birds were observed on the trees infested by the beetles, but the English Sparrow, which was the most numerous, did not feed on the insect in any stage of growth.

The only method of warfare against this pest recommended by European writers is to jar the larvæ down upon sheets, and then in one way or another to destroy them. This may answer for young trees, but is then tedious and but partial. We found that the quickest and most satisfactory way of destroying the insect and protecting the trees was by the use of Paris green and water in the manner frequently recommended in these columns, and London purple will evidently prove just as effectual and cheaper. The syringing can not be done from the ground except on very young trees, though a good fountain pump will throw a spray nearly 30 feet high. Larger trees will have to be ascended by means of a ladder and the liquid sprinkled or atomized through one of the portable atomizers, like Peck's, which is fastened to the body, and contains 3 gallons of the liquid.

The mode of pupation of the insect under the tree, on the surface of the ground, beneath whatever shelter it can find, or in the crevices between the earth and the trunk, enables us to kill vast numbers of the pupæ and transforming larvæ by pouring hot water over them. We found that even Paris-green water poured over them also killed. If the trees stand on the sidewalk of the streets the larvæ will go for pupation in the cracks between the bricks or at the base of the tree, where they can also be killed in the same way. This mode of destruction is, take it all in all, the next most satisfactory one we know of, though it must be frequently repeated.

(2) We have largely experimented with a view of intercepting and destroying the larvæ in their descent from the tree. Troughs, such as are used for Canker-worms, tarred paper, felt bands saturated with oil, are all good and the means of destroying large numbers. Care must be taken, however, that the oil does not come in contact with the trees, as it will soon kill them, and when felt bandages are used there should be a strip of tin or zinc beneath them. The trouble with all these intercepting devices, however, is that many larvæ let themselves down direct from the tree and thus escape destruction.

In conclusion we would remark that it is highly probable that Pyrethrum powder stirred up in water might be successfully substituted for arsenical poisons, but experiments in this direction have not yet been made. From experiments we have made with dry, unmixed powder, we found that it affects very quickly the larva, pupa, and the perfect insect, but in order to be applied on a large scale and on large trees the powder must of course be mixed in water. There is, however, no danger in the judicious use of the arsenical liquids upon shade trees.

MORE RECENT EXPERIENCE AT THE DEPARTMENT.

The more recent experience in the destruction of this *Galeruca*, on the Department grounds, may now be summed up, the experiments having been intrusted to Dr. Barnard.

Past History of the Elms in question.—According to Mr. William Saunders, of this Department, these trees have been annually attacked by the European Elm Leaf-beetle since they were planted ten years ago, and about one year in three the injury has been severe, resulting in their defoliation, while in other years, as in 1879 and 1880, there appeared comparatively none. In some seasons a second or autumnal set of leaves appeared after the trees had been stripped, and in certain of these instances the second crop of leaves became eaten; but in all cases he thinks the lives of the trees have not seemed to be endangered and they soon repaired the damage done. His belief is also that the pest did not become gradually worse and worse through the series of years during which it has been observed by him; still he regards the attack of 1882 as worse than any known to him before on these trees or others, and he has noticed the effects of this insect since 1850, first in its earliest ravages about Baltimore, and later elsewhere.

Condition and Characteristics of the Grove in 1882 and 1883.—However it may be for the past history or future desirability of certain trees in the grove, in 1882 many exhibited various grades of feebleness, and some had dying branches. Indeed, a few of them had a very unhealthy aspect the previous year also. Of course it can be claimed that their unhealthy condition is due to other causes than the insects; and it should be remembered that most are foreign species each often represented in two or more of its varieties. Here all grow on level ground, whereas in a state of nature some belong to mountainous localities, others to the damp climate of England, etc. Therefore, many of them are growing under abnormal conditions. They exhibit much variety in the relative abundance, size, form, and texture of the leaves. There is also great diversity in the density and form of branching.

Extent of Injury in 1882 and 1883.—All the varieties and species of elms in this grove, without exception, were preyed upon by the pest in 1882 and 1883. The insect, however, showed decided preferences for certain individual trees, varieties, or species, stripping some completely before doing more than very slight harm to the leaves of others, the former becoming completely eaten in midsummer, the latter not until toward the close of the season, or remaining only slightly damaged until then. In 1882 the leaves were eaten faster than they could be developed, and the insect continued abundant enough to prevent a second crop of foliage until in November, when it became too cold for the leaves and active insects to exist.

On these grounds the southeast side of each tree has suffered more than the northwest half. This peculiarity has been very strongly pronounced this year, 1883, on all the trees affected, and upon some examples far more markedly than upon others. This one-sidedness is especially apparent in the trees which were the most severely eaten. Some trees show the southeast side completely devoured but the northwest side only half consumed and comparatively green. Such are average cases.

The inferences have been that the shade, dampness, and coolness of the tree on the northwest side during the morning is too unhealthy for the favorable development of the larvæ or of the eggs deposited there; but whether this be true or not, the insect probably prefers to deposit chiefly in the middle of the forenoon, and on that part of the tree which is then warmest. This would give a greater number of the eggs at the outset on the southeast side, as observation seems to confirm, and since the young larvæ do not migrate to any noteworthy extent, the one-sidedness described would result whether the northwest side were unhealthy or not. The former explanation is most probably the correct one, as we have noticed that the insect is less injurious during very wet summers.

Preferences of the Elm Beetles for certain Varieties and Species of Elms.—The American slippery elm does not occur in this grove, but only one native species, the common American elm, *Ulmus americana.* This is practically free from the ravages of the beetle, on which account it may be preferred to the European species. It is tall, and has gracefully arched branches, making it as ornamental as any European kind, yet as a shade tree it does not equal the *U. montana* of the Old World. The latter has a broader, denser crown, but the attack on it is considerable, enough to leave the choice in favor of the American species.

U. montana seems the best European species grown here for shade, since the other foreign elms here cultivated are not dense enough. This applies to *U. campestris*, *U. suberosa*, *U. effusa*, and *U. parvifolia* (*siberica*). The last named is not attacked as much as the American. The young larvæ can not develop on it, but die quite soon, without growing, and they gnaw the leaves very little. The other foreign species mentioned are seriously eaten; the severest attack being upon the *U. campestris*, the favorite food of this insect.

As early as June 25, in 1883, this species was completely eaten and brown in our grove, at which date the *U. montana* examples retained more than half their verdure—in some individuals nearly all—and the common American elm was perfectly green. The *U. campestris* is one of the poorest elms for shade, and its total abolishment throughout the entire country would probably lessen the assault on *U. montana* to a comparatively unobjectionable extent. This measure should be instituted against the pest, and for the sake of the other species of elms.

Effects of arsenical Poisons on Insect and Plant.—Species of elms are somewhat differently affected by the poison. When treated alike there is always manifest some difference in the susceptibility of different elms to the corrosive effects of the poison. Even individuals of the same species or variety are differently impaired. As a rule, those which suit the insect best are injured most by the poison, and those which resist the insect most withstand the poison best. The latter have coarser foliage, with darker green color and more vigorous general growth; the former have more delicate foliage, lighter in color and weight, apparently less succulent.

Certain elms of the species *U. campestris* and other species which were overpoisoned, and shed most of their leaves in consequence in the last of June, 1883, sent out a profuse new growth of leaves and twigs. The foliage fell gradually for three weeks, and this was somewhat promoted by the succeeding rains.

The larvæ move from place to place so seldom that if the leaves are imperfectly poisoned from the mixture being weakly diluted, or from its application only in large scattered drops, which are much avoided by the larvæ, they are not killed off thoroughly for several days, and in all cases it requires considerable time to attain the full effect of the poison. This result appears on the plant and on the insect. After each rain the poison takes a new effect upon the plant and the pest, which indicates that the poison is absorbed more, or is more active when wet, and that it acts by dehydrating thereafter. Where the tree is too strongly poisoned, each rain causes a new lot of leaves to become discolored by the poison or to fall. On some of the trees the discoloration appears in brown, dead blotches on the foliage, chiefly about the gnawed places and margins, while in other instances many of the leaves turn yellow, and others fall without change of color. The latter may not all drop from the effects of poison, but the coloration referred to is without doubt generally from the caustic action. The poison not only produces the local effects from contact action on the parts touched by it, but following this there appears a more general effect, manifest in that all the foliage appears to lose, to some extent, its freshness and vitality. This secondary influence is probably from poisoning of the sap in a moderate degree. When this is once observable, no leaf-eater thrives upon the foliage. Slight overpoisoning seems to have a tonic or invigorating effect on the tree.

Preventive Effects of the Poison.—In this grove the elms that were poisoned in 1882 were attacked in the spring of 1883 less severely than were those which were not poisoned the previous year. This would seem to imply that the insects deposit mostly on the trees nearest to where they develop, and are only partially migratory before ovipositing. The attack afterward became increased, probably by immigration and the new generation, so that later in the season the trees were mostly infested to the usual extent.

In the region of Washington *a preventive application of poison should be made* before the last of May or first of June, when the eggs are being deposited and before they hatch. This will prevent the worms from ever getting a start. By the preventive method the tree escapes two kinds of injury: first, that directly from the eating by the insect; second, that which follows indirectly from the deleterious effects of the poison on the plant, for its caustic effect is much greater where the leaves have been so gnawed that the poison comes in contact with the sap.

Treatment with London Purple.—Already early in June the insect appears plentiful. On June 7, 1882, it was at work on all the trees, and

its clusters of eggs were numerous beneath the leaves. Some of the trees had half of the leaves considerably gnawed and perforated by larvæ of all sizes, and by the adults. At this date fifteen trees, constituting the south part of the grove, were treated.

Preparation of the Poison.—London purple (one-half pound), flour (3 quarts), and water (barrel, 40 gallons) were mixed, as follows: A large galvanized iron funnel of 13 quarts capacity, and having a cross-septum of fine wire gauze such as is used for sieves, also having vertical sides and a rim to keep it from rocking on the barrel, was used. About 3 quarts of cheap flour were placed in the funnel and washed through the wire gauze by water poured in. The flour in passing through is finely divided, and will diffuse in the water without appearing in lumps. The flour is a suitable medium to make the poison adhesive. The London purple is then placed upon the gauze and washed in by the remainder of the water, until the barrel is filled. In other tests the flower was mixed dry with the poison powder, and both were afterward washed through together with good results. It is thought that by mixing in this way less flour will suffice. Three-eighths of a pound of London purple to one barrel of water may be taken as a suitable percentage. Three-eighths of an ounce may be used as an equivalent in one bucketful of water. The amount of this poison was reduced to one-fourth of a pound to the barrel with good effect, but this seems to be the minimum quantity, and to be of value it must be applied in favorable weather and with unusual thoroughness. With one-half or three-fourths of a pound to the barrel about the maximum strength allowable is attained, and this should be applied only as an extremely fine mist, without drenching the foliage.

Effects of the Mixture.—The flour seems to keep the poison from taking effect on the leaf, preventing to some extent the corrosive injury which otherwise obtains when the poison is coarsely sprinkled or too strong. It also renders the poison more permanent. On the leaves, especially on the under surfaces, the London purple and flour can be seen for several weeks after it has been applied, and the insect is not only destroyed, but is prevented from reappearing, at least for a long period. By poisoning again, a few weeks later, the insect is deterred with greater certainty for the entire season. By being careful to administer the poison before the insect has worked, and, above all, to diffuse the spray finely but not in large drops, no harm worth mentioning will accrue to the plant from the proportion of poison recommended. The new growth that developed after the first poisoning was protected by one-fourth of a pound to the barrel in 1882. From midsummer until autumn the unpoisoned half of the grove remained denuded of foliage, while the poisoned half retained its verdure. The little damage then appearing in the protected part was mostly done before the first treatment. Eggs were laid abundantly throughout the season. Many of these seemed unhealthy and failed to develop, probably because they were poisoned. Many hatched, but the young larvæ soon died. The

eggs were seldom deposited on the young leaves that were appearing after the poison was applied, but were attached to the developed leaves, and here the larvæ generally got the poison to prevent their attack upon the aftergrowth. Still the young leaves became perforated to some extent. The adults, which fly from tree to tree, appeared plentiful without much interruption throughout the season, and often several could be seen feeding on each tree. Possibly many of these may have become poisoned before depositing the eggs.

The efficiency of London purple being established, it will generally be preferred to other arsenicals, because of its cheapness, better diffusibility, visibility on the foliage, etc. As the effects of the poisons commonly do not appear decidedly for two or three days after their administration, the importance of the preventive method of poisoning in advance can not be too strongly urged. As the effect is slow in appearing, impatient parties will be apt to repoison on the second or third day, and thus put on enough to hurt the plant when the effect does come. Much depends on dryness or wetness of the weather, but good effects may be expected by the third or fourth day.

London purple seems to injure the plant less than Paris green.

Treatment with Paris Green.—In 1883 the Paris green was first applied on the 29th of May, at which date the eggs were extremely abundant and hatching rapidly on the leaves. Paris green, flour, and water were mixed by the means previously employed with London purple and already described. The mixture was applied to the north part of the same grove of elms. Thus far experience shows that the Paris green is effective against the insect, but that this poison injures the plant more than does the London purple.

Three-fourths of a pound of Paris green to a barrel (36 or 40 gallons) of water, with 3 quarts of flour, may be regarded as a poison mixture of medium or average strength for treating elms against these beetles, and the indications thus far are that the amount of Paris green should not be increased above 1 pound or be diminished much below one-half a pound in this mixture. To a bucketful of water three-fourths of an ounce of Paris green may be used. The action of this poison is slow but severe, and varies much with the weather. Thus far the results of tests have been varied so much by the weather and different modes of preparation and application that they will be repeated. When used strong enough to cauterize the leaves the poisonous action upon the plant may be observed to continue for several weeks.

Mechanical Means of Applying the Poison.—When many trees were to be sprayed a cart or wagon was employed to haul the poison in a large barrel provided with a stirrer, force-pump, skid, etc. The following brief account of the skid, mixer, barrel, and pump may be reproduced here from our last Annual Report:

The skid is a simple frame to hold the horizontal barrel from rolling, and consists of two pieces (Pl. I, Fig. 3 *a a*) of wood, about the length of the barrel, and in section about 3 by 4 inches, joined parallel, apart from each other, by two cleats, *b b*. The

inner upper angles may be cut to match the curve of the barrel, as at *c c*. The barrel being placed upon this frame is next to be filled.

A good device for mixing the poison thoroughly with the water and for filling the barrel is shown in section in Pl. I, Fig. 4. It consists of a large funnel that will hold a bucketful, and has cylindrical sides, *g g*, that rest conformant on the barrel. In this is a gauze or finely perforated diaphragm or septum, *d*, and a funnel base, *t t*, with its spout, *p*, inserted through the bung.

By reference to Pl. I, Fig. 4, the barrel, *k*, will be seen in section, and some of its details, together with those of the pump and stirrer, may be noticed. The fulcrum, *f*, has a foot below, screwed to the barrel. Through its top is a pivot, *o*, on which tilts the pump-lever, *i i*, which is similarly hinged at *b* to the top of the piston-rod. The pump-cylinder, *q*, is also hung upon trunnions, *i*, projecting into eyes. In this illustration the eyes, *e e*, have each a neck fitting in a slot cut through the stave oppositely from the side of the bung-hole, and beneath the stave is a foot on the eye-piece. Its neck is so short that the eye is held down firmly against the top of the stave, while the foot is as tight against its under surface. The length of its eye-piece is a little less than the diameter of the bung-hole, into which it may be inserted to be driven laterally into the slot. The slot is longer than the eye-piece, so the latter may be driven away from the bung-hole for a distance greater than the length of the trunnion-pivot. Then the pump being inserted, until these pivots come opposite the eyes, the latter may be driven back as sockets over the pivots, which play in them when the pump is worked. To hold these eyes toward the pump and upon the trunnions a wedge, *v*, is driven in the slot beyond each eye-piece. Thus the pump is easily attached or removed, and its union with the barrel is strong and firm. Perchance it be desired that this pump hole be bunged, the side slots may be wedged to make the barrel tight.

The parts of the pump being hung as described, the hinge, *b*, forms a toggle-joint, and in its action causes the pump to oscillate on its trunnions, its basal end swinging wider than its top, as indicated by the dotted line from *x* to *y*. Upon the extremity of this swinging end is a loop, *h*, through which is passed a stirrer-bar, *m n*, made to sweep back and forth in the lower side of the barrel, thus to agitate and mix the substances considerably during the operation of the pump, every stroke of the handle causing one or two strokes of the stirrer.

The method of inserting and extricating the stirrer-bar is as follows: It is raised with the pump until the end, *n*, comes opposite the bung-hole, through which the bar may be pulled out by the cord, *w*, which is attached to the end, *n*, and also preferably to the bungs, *r* and *z*, as shown. Through the same hole the bar may be inserted. This stirring device is the simplest in construction and operation of any yet contrived, while working as it does with reference to the concavity of the barrel it is perfectly effective.

The pump is double acting and very powerful, giving strong pressure to disperse the liquid far and finely, for, with the eddy-chamber nozzle used, the greater the pressure the finer is the liquid atomized. A block or other catch may be fixed on the side of the barrel to fit against the skid and prevent the barrel from rocking therein, as might otherwise happen, when it is nearly empty, if much power is applied. About one pailful of poisoned water was sprayed upon each tree. When only two or three trees were to be treated, an aquapult or other bucket-pump was used to force the poison from a bucket carried by hand. The Paris-green mixture needs to be almost constantly stirred, as this poison precipitates quickly; but with London purple the agitation is only occasionally necessary.

Connected with either pump is a long, flexible pipe, with its distal part stiff, and serving as a long handle whereby to hold its terminal nozzle beneath the branches or very high up at a comfortable distance from the person managing it. Parts of one form of this extension pipe are shown in Figs. 1 and 2.

To the pump-spout is attached the long, 2-ply, flexible hose, *h h*, of ¼-inch caliber. Its considerable length, 12 feet or more, allows the nozzle to be carried about the tree without moving the pump. Beyond its flexile part the hose, *h*, passes through a bamboo pole, *b*, from which the septa have been burned out by a hot iron rod. At the distal end of the pole the hose terminates in a nozzle, *n* or *m*. When the nozzle is in its natural position, *m*, the spray, *z*, is thrown straight ahead, and this suits well for spraying very high branches; but for spraying the under surfaces of the lower parts of the tree it is necessary that the nozzle discharge laterally from the pipe, and this is accomplished with a nozzle having a direct discharge by bending it to one side. The nozzle, *n*, and spray, *s*, are directed laterally, and the nozze, *n*, is maintained in this position by a metallic hook or eye, *v*, having a crooked stem inserted at the side of the hose in the end of the pole. Where the side spray is permanently desired, the metallic stem is inserted inside the hose and connected with the base of the nozzle, or the tubular stem of the nozzle is given the desired crook. For small trees the simpler extension pipe shown in Fig. 2 is satisfactory. The metallic tube, *t*, several feet in length, is used as the stiff part, *t*, connected with the hose, *h*. One longer metallic pipe, having telescopic sections made tight by outside segments of rubber tubing, has also been employed, and is a very desirable extension-pipe. Where only low-end spraying is to be done, as upon small trees, etc., the eddy-chamber nozzle is set upon such a pipe, or upon its own stem, so as to discharge at right angles therefrom; but a diagonal position of the chamber, *n*, on its stem, *i*, throws the spray, *s*, at an intermediate angle between the right angle and a direct line, by which, without any readjustment, the spray, *s*, can be directed high or lower, beneath the foliage or above. For general use this kind of nozzle is the best. With ordinary force-pump pressure the discharge hole of the nozzle is about one-sixteenth of an inch in diameter for misty sprays with particles invisibly small. Rather than use the larger, coarser sprays, which were usually employed in these tests, it is better to use the finest spray. The spray falling upon the extension-pipe soon accumulates enough to flow down the pole and wet the hands. To prevent this a wrapping washer of leather or other flange may surround proximally from the spray, and the drip will drop off from its margin. Such an arrangement is indicated at *j* in Plate I, Fig. 1.

While one person operates the pump, another, standing in the vehicle or upon the ground, directs the spray by the stiff part of the pipe. Thus the operator can not only spray higher and lower with convenience, but he can to a great extent move the spray from place to place without

leaving his own position and without moving the vessel of poison with the pump.

The hose and bamboo combination was conceived of and used as the lightest long stiff tube practicable for these purposes, and it has answered admirably. A similar pole, with a metallic tube in its interior, with a nozzle not producing the very fine mist desired, and lacking the side discharge, etc., was afterward learned of as being used in California. (See U. S. Agricultural Department Report, 1881–'82, p. 208.)

By the apparatus used, when everything is prepared, a tree can be sprayed quickly, and a large grove is treated in a short time. It is equally adapted for forestry use in general, and likewise available for poisoning on fruit trees, when not in fruit, while the shorter style of extension pipe is convenient for underspraying all kinds of low plants.

APPENDIX.

One statement in the life history of the Imported Elm Leaf-beetle, as given in the preceding pages, may have to be corrected in the light of the observations of the past six years, and that is in reference to the number of annual generations. Like other leaf-beetles, this insect occupies an extended time in oviposition. The eggs appear to develop slowly in the ovaries, and a single female will deposit a number of the characteristic little yellow batches. This fact, taken in connection with the retardation of certain individuals of a generation, results in an inextricable confusion of broods. Adult beetles, pupæ, larvæ in all stages, and eggs, will be found upon trees at the same time in Washington during the months of June, July, August, and even later. From this fact it is almost impossible to estimate the number of annual generations without the most careful breeding-cage experiments. There is no evidence that the facts upon record are based upon such careful experiments. Glover, in the annual report of this Department for 1867, page 62, says: "After becoming pupæ, in a few days the skin of the back splits open and the perfect insect crawls forth, furnished with wings, by means of which it is enabled to fly to other trees and deposit its eggs, thus spreading the nuisance to every elm in the neighborhood; or it may ascend some tree and lay the eggs for a *second generation*, which destroys the second crop of leaves, frequently so enfeebling or exhausting the tree that it is unable to recover and eventually perishes." Again, in the Annual Report for 1870, page 73, he says: "The perfect beetles appear in a few days and immediately fly up into the tree to lay their eggs for a *second generation*, which frequently destroys every leaf on the tree."

The European records seem strangely silent upon this point. In the articles by Leinweber and Frauenfeld, referred to upon page 6, there is no indication of the number of generations, but it may be inferred that only one, namely, that of June and July, has been under observation. Heeger, however (*loc. cit.*, p. 114), says that "Under favorable circumstances there are three to four generations during the whole summer. Toward the end of August the insect ceases feeding and retires—partly as larvæ and partly as beetles—to winter rest under fallen leaves, in the cracks of bark, holes in the trunks of the trees, and in the ground itself." This observation was made near Vienna.

Our statement upon page 8 was a general one, based upon the ob-

served shortness of the larval life, and upon the fact that the earliest larvæ mature before the end of May, and upon the additional fact that we know that newly developed beetles are found early in June. Prof. John B. Smith, in a paper read before the Entomological Club of the American Association for the Advancement of Science, in August of this year, made the statement that there is but one annual generation in New Jersey. The adult beetles develop from the larvæ which have fed during the summer, entering winter quarters as early at the first week in August. This state of affairs may probably hold in more northern regions, but in Washington it is safe to say that there are two generations, because, as just stated, newly developed beetles (the progeny of those which hibernate) appear in early June. These lay eggs, and, in fact, egg-laying may continue until the end of September, and larvæ have actually been found by Mr. Pergande in October.

REMEDIES.

The spraying with arsenical poisons recommended in this bulletin has been generally adopted, and with universal success where proper precautions have been observed and where sufficient care has been taken. The most careful record of experiments that has been published was recorded by Prof. Smith in *Garden and Forest* for June 19, 1889. Prof. Smith's experience was interesting, not only because he treated some very large trees upon the Rutgers College campus, but from the fact that he has introduced a variation in the way of adding a small quantity of kerosene emulsion to the arsenical mixture for the purpose of making it spread over the leaves to wet them thoroughly. The dense velvety pubescence characteristic of the under side of certain elm leaves causes them to shed water readily, and this difficulty is overcome by the addition of the oil. The formula which he recommends is water, 100 gallons; London purple, 1 pound; standard kerosene emulsion, 1 gallon. This mixture he has found does not injure the foliage at New Brunswick. It is, however, stronger than is necessary, and the same amount of London purple and kerosene emulsion may be added to 150 or even 200 gallons of water with almost equal efficacy and with much greater safety. The difficulty of reaching the tops of tall trees was overcome by Prof. Smith in the following way: He used a hose 50 feet in length, to the end of which was attached a proper nozzle. The upper 10 feet were fastened to a bamboo pole of this length. With this he was able to throw a spray upon all branches 20 feet and over from the ground. Removing the spraying nozzle a solid jet could be thrown among the higher branches. This solid jet, he found, broke into quite a fine spray about 25 feet from the ground, and wetted the branches thoroughly to a height of 30 feet. A light ladder 20 feet in length gave him access to the center of the largest trees, whence the extreme tops could be reached. For the largest trees he used about 20 gallons of the mixture just mentioned. He was successful in destroying all the beetles and larvæ, and most of the eggs.

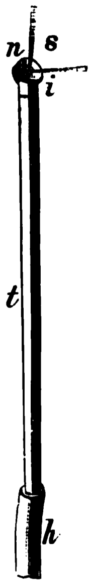

FIG. 2.

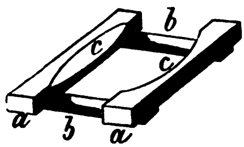

FIG. 3.

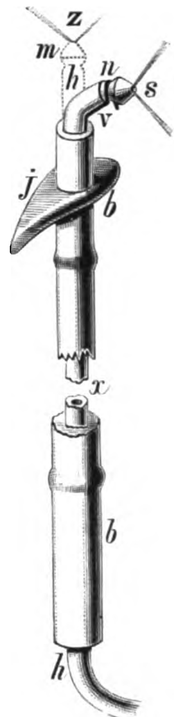

FIG. 1.

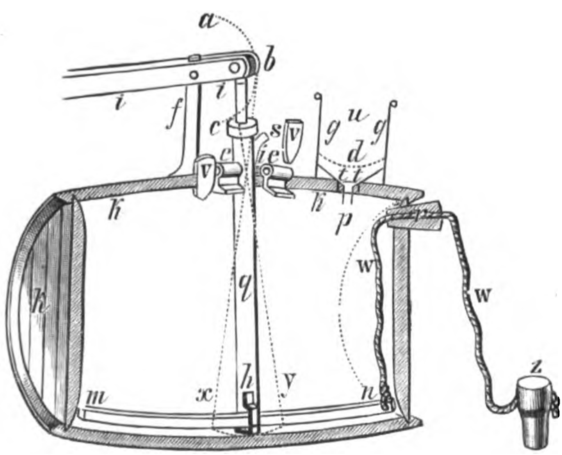

FIG. 4.

DEVICES FOR UNDERSPRAYING TREES.

Plate I.

DEVICES FOR UNDERSPRAYING TREES WITH INSECTICIDES.

[From Ann. Rept. U. S. Dept. Agr., 1883.]

FIG. 1. *Parts of hose-pole device for spraying trees:* Bamboo pole, *b b;* drip-washer, *j;* hose, *h x;* side hook, *v;* eddy-chamber nozzle, *n m;* spray, *z s.*

FIG. 2. *Metallic hand-pipe with diagonal nozzle:* Hose, *h;* metallic pipe, *t;* diagonal eddy-chamber nozzle, *n;* its removable face, *i;* spray, *s.*

FIG. 3. *Barrel rest or skid:* Two coupling-cleats, *b b;* two side rests, *a a;* chamfered concave, *c c.*

FIG. 4. *Stirrer-pump with barrel and mixer-funnel in section:* Funnel, *u;* its cylindrical sides, *g g;* funnel base, *t t;* spout, *p* (in bung-hole, *k*)*;* gauze septum, *d;* barrel, *k k;* trunnions, *i;* trunnion-eyes, *e;* wedge, *v;* lever-fulcrum, *f;* pump-lever, *i i;* swing of the lever-head and piston-top, *a b c;* cylinder packing-cap, *c;* cylinder, *q;* its swing, *x y;* stirrer-loop or eye, *h;* stirrer-bar, *m n;* rope, *w w;* bungs, *r z.*

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN NO. 7.

THE

PEDICULI AND MALLOPHAGA

AFFECTING

MAN AND THE LOWER ANIMALS.

BY

PROF. HERBERT OSBORN.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

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1891.

CONTENTS.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., November 28, 1890.

SIR: I have the honor to submit for publication Bulletin No. 7, on the Pediculi and Mallophaga affecting man and the lower animals, by Prof. Herbert Osborn, the Iowa agent of the Division.

In explanation of the numbering of this bulletin it is necessary to state that Bulletin No. 7 was originally intended to cover a monograph by myself of the genus Acronycta, a genus of Noctuidæ popularly known as "daggers," and the larvæ of which are, many of them, quite destructive to forest trees. The manuscript and figures of this monograph have been, for the most part, prepared for several years, and I have hoped each year to be able to put them in the printer's hands; but more urgent divisional work has caused continued postponement, and in order to avoid the hiatus which the delay has caused in the series of special bulletins I have deemed it best to call the present bulletin No. 7.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTORY NOTE.

The matter included in the following pages was written to form part of a report upon the insects affecting vertebrate animals, which was begun as a conjoint work by Dr. Riley and myself.

Various circumstances having delayed the completion of the report, Dr. Riley has requested that this portion be put in print under my signature.

The publication of this portion singly makes me responsible for the matter presented, but I wish to acknowledge the many favors received from Dr. Riley which have facilitated the work and made it certainly better than it could otherwise have been.

The figures have in most cases been sketched by the author and finished under Dr. Riley's supervision by Miss Lillie Sullivan. A certain number have been copied from other works, and these will be found duly credited in their place.

HERBERT OSBORN.

WASHINGTON, D. C.,
July 8, 1890.

ORDER HEMIPTERA.

SUBORDER PARASITA.

This group includes the suctorial lice, confined to mammals; they are strictly parasitic insects, being confined to their hosts constantly, and deriving all their nourishment from them. They are wingless, and the mouth parts consist of a tubular suctorial organ.

This suborder contains but two families, the first of which, the *Polyctenidæ*, contains, so far as known, but two species, both of which are confined to bats, one in Jamaica and the other in China. These do not properly fall within the province of this paper, and it will not be necessary to give them further consideration.

FAMILY PEDICULIDÆ—THE SUCTORIAL LICE.

This family includes nearly all the species of the suborder and all that come within the limits of this paper.

We need only add to the character above given the short rostrum without joint and the tarsi adapted to clasping and holding to hairs.

The eggs, "nits," are attached to hairs by a glue-like substance, and the young lice when hatched resemble the adults except in size. As the entire life of the parasite is passed upon the same animal or on another animal of the same kind, its range of habit is easily stated.

But very few of the species are ever found upon any other species of animal than that which they normally infest, and if so always upon very nearly related species. Whether this is due to differences in the thickness of the skin, of temperature, of the size of the hair to which they must adhere and to which their feet are adapted, or to some subtle difference in the odor or taste peculiar to their particular host which leads them to discard all others, we are unable to say.

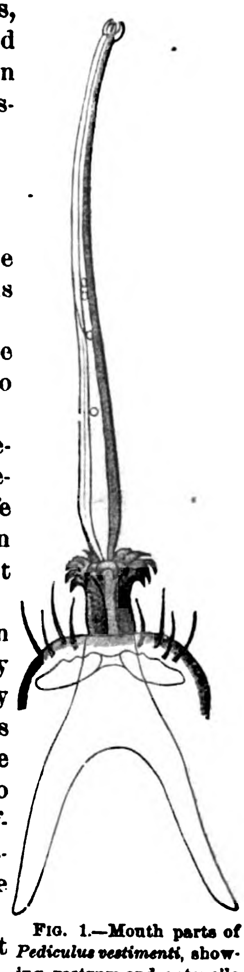

FIG. 1.—Mouth parts of *Pediculus vestimenti*, showing rostrum and extensile tube—greatly enlarged.

The mouth parts are necessarily capable of great extension in order to reach the blood of their hosts. Uhler says (Standard Nat. Hist., II, p. 209): "A fleshy unjointed rostrum, capable of great extension by being rolled in-

side out, this action serving to bring forward a chaplet of barbs which imbed themselves in the skin to give a firm hold for the penetrating bristles, arranged as chitinous strips in a long, slender, flexible tube, terminated by four very minute lobes, which probe to the capillary vessels of a sweat pore (see Fig. 1). The blood being once reached a current is maintained by the pulsations of the pumping ventricle and the peristaltic movements of the stomach."

The species infesting man are so nearly related to the others that we can not well pass them by without notice.

THE CRAB LOUSE.

(*Phthirius inguinalis* Leach.)

If we may depend upon ancient writers this species has been a long companion of man. According to Denny it is recorded by Herodotus, and according to Piaget was referred to in the writings of Aristotle. Some of the ancient accounts treat of it as occurring in the most prodigious numbers and causing most serious ailments to the infested parties. The disease produced gained the name of *Phthiriasis*, though doubtless this term has been applied also to the attacks of the other species of parasites infesting man.

Its attacks are said to be more severe than those of the other forms of lice, though it is quite probable that in the worst cases reported the different species have been present, since the conditions favoring the increase of one will favor also the others. The reports, especially of the earlier writers, have many of them doubtless been subject to great exaggeration, for while the normal rate of increase will account for the sudden appearance and rapid multiplication of the lice under certain conditions, it is not equal to the marvelous stories which are to be met with even in some works that lay claim to accuracy.

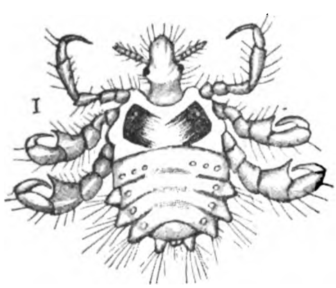

FIG. 2. *Phthirius inguinalis* (After Denny from Murray).

The crab louse infests particularly the pubic regions, but occurs also among the stiff hairs under the arms, in the beard, and it is said also among the hairs of the eyebrows. It does not live in the fine hair of the head.

It is very distinct from the other species, the body being nearly as wide as long, while the strong legs spreading out laterally very greatly increase its apparent width and gives it the form of a crab in miniature, thus winning for it the name of crab louse. It is of a whitish color, with a dusky patch on each shoulder, and with the legs slightly tinged with reddish, the claws having this color more pronounced. It is nearly one-tenth of an inch in length.

The remedies adopted for the head louse are applicable to this species, though it is said they are less effectual and must be persisted in more vigorously. Red precipitate is probably most frequently used.

THE HEAD LOUSE.

(*Pediculus capitis* De Geer.)

This louse has been recognized under one name or another as far back as we have history. While very generally confused with the following species it is probably the one most commonly known, though perhaps not the one which has caused the greatest amount of annoyance or that has occurred in the greatest numbers. The two species were not clearly defined till comparatively recent times.

Elaborate writings upon the louse were given by Swammerdam, Leeuwenhoek (1693), and descriptions of it by Redi, DeGeer, Linné, Geoffroy, Burmeister, Leach, and others, besides innumerable brief mentions and a goodly number of elaborate memoirs upon its embryology, etc. In later days, while a most annoying pest, it does not appear to have caused such serious results as the body louse or the crab louse.

FIG. 3.—*Pediculus capitis* (after Packard).

It is confined to the fine hair of the head, rarely occurring on other parts of the body.

The eggs (nits) are white and glued to the hair at some distance from the head, and are most abundant, we have observed, back of the ears. When numerous they form quite conspicuous objects. The young upon hatching from these resemble the adults, except in size and in being less distinctly marked. The proportions of the body are also somewhat different, the abdomen being smaller than after it has become enlarged by a steady diet upon human blood. The full grown lice are whitish, with faint dark markings at the sides of the thorax and abdomen. The last segment of the abdomen in the female is bilobed.

Murray has shown that the different races of man harbor different varieties of this species of louse, the difference in the varieties being particularly in color and in the form of the claws. In color they differ from the nearly white infesting Europeans to the black infesting the African. The claws differ somewhat in proportions and Murray thinks these differences constant, but they can at most be considered only as varietal differences.

Remedies are white precipitate, sulphur ointment, and especially cleanliness.

THE BODY LOUSE.

(*Pediculus vestimenti* Leach.)

As with the preceding species the history of this parasite is lost in antiquity, and most of the early accounts failed to indicate any differ-

ence in the two forms. In the works of DeGeer, Leach, Denny, and others they are distinguished and well characterized.

This form is most common where opportunities for good sanitation are wanting, as in armies, prisons, and all places where attention to bodily cleanliness from choice or necessity is neglected.

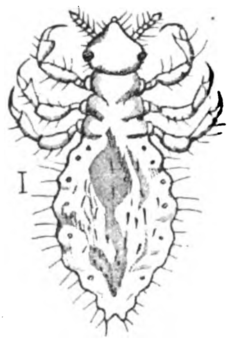

Fig. 4. *Pediculus vestimenti* (after Denny).

It is not known to infest other animals, though we have seen specimens that were said to have been taken from cattle.

Until fully grown there is not much difference to be noted in the appearance of this and the preceding species, though the markings at the sides are less distinct. In the adult forms, however, the dorsal surface is marked with dark transverse bands.

The insect secretes itself in the folds of the clothing, only penetrating the skin when in want of food. The long, slender sucking tube, by means of which it reaches the small blood vessels near the surface, is shown fully extended in Fig. 1.

The eggs are deposited in folds of the clothing, and, according to the estimates of Leeuwenhoek, a single adult female may have a progeny of 5,000 in 8 weeks, and he adds that in the heat of summer this estimate might be very greatly exceeded. This will readily account for all the authentic accounts of sudden and numerous appearances of this pest.

A ready means of combating this pest is to thoroughly bake the clothing infested with it, or, to be fully as effectual with less heat, this might be accompanied by fumigation with sulphur or tobacco smoke. A repetition of this process two or three times at intervals of a few days, along with strict personal cleanliness, should overcome the most serious attack.

Alt describes, under the name of *Pediculus tabescantium*, the louse, which he considered as the cause of phthiriasis, but later authorities consider this as simply the *vestimenti* present in aggravated numbers. Properly speaking, this affection should be termed *Pediculosis*, and the term phthiriasis reserved for the attacks of *Phthirius inguinalis*.

LOUSE OF THE APE.

(*Pediculus consobrinus* Piaget.)

Closely related to the human lice is a species described by Piaget occurring upon the Ateles ape (*Ateles pentadactylus*). It resembles especially the *Pediculus capitis*, but presents some differences in form of head and structure of abdominal appendages which have led this author to establish the separate species. It appears to differ less, in general appearance, from typical *capitis* than the varieties of *capitis* occurring on different races differ among themselves.

Though there is considerable difference in the drawings, this is probably the same species as figured by Murray (Economic Entomology, p. 389) under the name of *Pediculus quadrumanus* and said to be taken from the Ateles ape.

LICE INFESTING THE MONKEY.

(*Pedicinus* sp.)

Three species of lice are found upon monkeys, all being generically distinct from those infesting other animals. They form the genus *Pedicinus*, the most essential character of which is the presence of but three joints in the antennæ.

The species are the *Pedicinus eurygaster* Gervais, which occurs upon the Macaques, *Macacus nemestrinus*, *cynomolgus*, and *radiatus*, according to Piaget, and *Macacus sinicus*, according to Giebel; *Pedicinus longiceps* Piaget, occurring according to its author upon the *Macacus cynomolgus* and the *Semnopithecus pruinosus;* the *Pedicinus breviceps* Piaget, infesting the *Cercopithecus monas*.

Aside from these species of *Pedicinus*, Gervais describes a species of *Hæmatopinus*, *H. obtusus*, from the *Semnopithecus maurus*.

The abundance of these vermin upon monkeys can be attested by all visitors of zoölogical gardens or menageries, and the ready means adopted by the hosts for their subjugation are equally familiar—a method of destruction which, by the way, is said to be adopted by many tribes of inferior races belonging to the human species.

THE SUCKING DOG-LOUSE.

(*Hæmatopinus piliferus* Burmeister.)

Although the dog has been the closest companion of man among the domestic animals from very early times, and consequently this parasite in all probability well known to keepers of dogs, it was not technically described until about the year 1838.

It does not appear to have been a very numerous or injurious parasite, apparently much less so than the *Trichodectes latus* infesting the same animal, and less annoying than either ticks or fleas. Denny says (Monog. Anop. Brit., p. 29), "I have found it upon dogs two or three times, but it is by no means of common occurrence." We have examined many dogs in quest of it, but only a single specimen so far has been our reward. Denny says (loc. cit.), "I also received specimens from the ferret." It can hardly be inferred, however, that this animal is consequently a normal host for the species, as such an instance might occur entirely from accident, the louse having been transferred from some dog to a ferret associated with it.

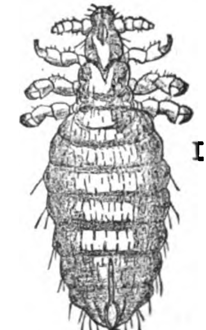

FIG. 5.—*Hæmatopinus piliferus*. (Original.)

This species is somewhat smaller than the lice infesting most of the larger mammals, the full-grown individuals being nearly one-tenth of an inch long. It is described generally as of a light-red or ashy flesh color, but evidently varies as the other species, according to condition of the body as well as age of specimens. In preserved specimens these colors become lighter, assuming a yellowish hue, the abdomen, except where darkened by the intestine and its contents, appearing a shade lighter than the front part of the body. The abdomen is thickly covered with fine hairs and minute warty eminences, these latter when magnified about 300 diameters appearing like the scales of a lizard or fish.

Specimens from different breeds of dogs do not appear to have been noticed as different, though a form described as *H. bicolor* by Lucas may perhaps be found to present race characteristics.

THE LOUSE OF THE CAMEL.

(*Hæmatopinus cameli* Redi.)

We follow Giebel and Piaget in admitting this species, though it does not appear to have been observed by any modern naturalist.

Piaget says (Les Pedic., p. 644): "La figure que donne Redi, le seul qui ait observé cette espèce, se rapproche beaucoup de celle de l'*urius*."

LICE INFESTING THE GIRAFFE, DEER, AND ANTELOPE.

(*Hæmatopinus* sp.)

Closely related to the lice infesting the other hoofed quadrupeds are the lice infesting respectively the giraffe, deer, and antelope. The species infesting the giraffe (*Camelopardalis giraffa*) was described by Giebel under the name *Hæmatopinus brevicornis;* that infesting the deer was first mentioned by Redi and described and named by Nitzsch as *Hæmatopinus crassicornis;* it is recorded from the red deer (*Cervus elaphus*). The *Hæmatopinus tibialis* Piaget, from *Antilopa maori*, is, according to its author, represented by varieties on the *Antilopa* sp. and the *Antilopa subcutturosa*, and he considers it possible that the *H. cervicapræ* Lucas, from *Antilopa cervicapra*, is also a variety of this same species.

THE SUCKING LOUSE OF THE GOAT.

(*Hæmatopinus stenopsis* Burmeister.)

We have no record of this species having been observed in this country, and judging by the references to it in standard works it must be of rather rare occurrence in countries where these animals are kept in greater abundance than here.

The species is not, so far as at present known, transmissible to any other domestic animal, and if ever becoming abundant will doubtless

yield to the treatment used for the other species, though the long hair would make some of them more difficult of application. On this account fumigation where possible would seem to be most practicable.

THE SHORT-NOSED OX-LOUSE.

(*Hæmatopinus eurysternus*, Nitzsch.)

This is the species that has probably been familiar from early time as the louse infesting cattle, though since this species and the following one have been generally confused, it is impossible to say which has been most common. It was first accurately described by Nitzsch under the name of *Pediculus eurysternus*, in 1818 (Germar's Mag., vol. III, p. 305), and has received mention in every important treatise on parasites since that date, as well as innumerable notices under the head of animal parasites, cattle lice, etc. As with other species, the disease produced has been termed phthiriasis, and as treated by Kollar and other writers it has been recognized as a most serious pest and numerous remedies tried for its suppression.

Since it has been very generally confused with the following species we shall give more particular description and show as clearly as possible how to distingush them. The following quotation from Mr. C. W. Tenney (in Iowa Homestead for August 18, 1882) will show that this difference is not without interest or value as viewed by a practical breeder: "Then there is a blue slate-colored louse and a larger one of the same color that vary somewhat in their habits, and the last-mentioned is the hardest to dislodge." Evidently it is the species under discussion to which Mr. Tenney refers as the "larger one." It infests particularly the neck and shoulders, and these parts are frequently worn bare by the efforts of the animal to rid itself of the irritation produced by these unwelcome visitors. Still, some cattlemen say that these parasites are of no consequence, and that they never pay any attention to them.

The full-grown females are about one-eighth to one-fifth of an inch long, and fully half that in width, while the males are a little smaller and proportionately a little narrower. Aside from the difference in size the sexes differ very decidedly in the markings and structural features upon the under side of the body. The males have a broad black stripe running forward from the end of the body to near the middle of the abdomen, as shown in Fig. 6*c*.

The females have no indications of this stripe, but the black broken band of the upper side of the terminal segment extends slightly around on the under side. The most important character, however, is the presence of two little brush-like organs on the next to the last segment, as shown in Fig. 6*d*.

The head is bluntly rounded in front, nearly as broad as long, and with the antennæ situated at the sides midway from the posterior to the

anterior borders; behind these are located slight eminences upon which may be found the small eyes, which are seen with considerable difficulty. At the front of the head may be seen the small rostrum or beak, the end of which is usually at or near the surface, but which is capable of extension and retraction. The end of this beak is armed with a double row of recurved hooks (see Fig. 6*b*). The function of these hooks is

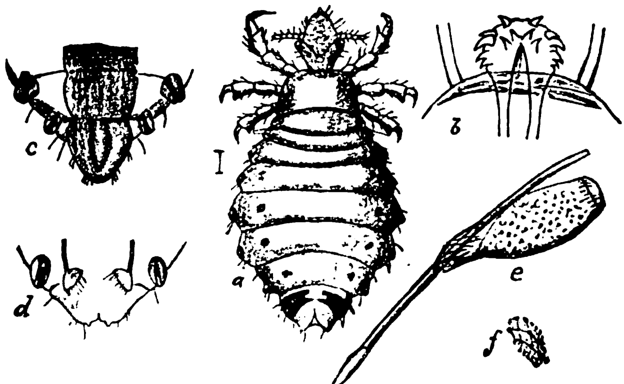

FIG. 6.—*Hæmatopinus eurysternus; a*, female; *b*, rostrum; *c*, ventral surface last segments of male; *d*, female; *e*, egg; *f*, surface of egg greatly enlarged. (Original.)

doubtless to fasten the beak firmly into the skin of the host, while the true pumping organ must consist, as in the *Pediculi*, of a slender piercing tube, though we can see only slight indications of this tube within the head, and we have not seen it nor do we find any record of its having been seen fully extended in this species. Professor Harker says the rostrum can be pushed out, but his figure shows only the basal portion with the crown of hooks and nothing of the tubular parts inclosed within.

The thorax is wider than long and widest at the posterior margin where it joins the abdomen. The legs project from the side, are long and stout, and especially adapted to clasping and clinging to the hair. An extra provision for this purpose consists of a double plate having fine transverse ridges in the basal joint of the tarsus. This structure appears to have been first described by Professor Harker (Agricultural Students' Gazette, vol. I, p. 162). The abdomen differs greatly in form and size, according to the degree of distention, which accounts for the discrepancies in the different figures of this species. It may be called flask-shaped and more or less flattened according to the amount of matter contained in it. There is a row of horny tubercles along each side and a row of chitinous plates along each side of the upper surface of the abdomen. The spiracles are located in the tubercles at the sides, and there is one to each of the last six segments omitting the terminal one. In color there is some variation, as would be surmised from a comparison of descriptions by different authors. The general color

of the head and thorax is a light brown approaching to yellowish, with touches of bright chestnut on the head and legs and margins of the thorax, also touches of dark brown on these parts, more particularly on the dorsal portion of the thorax. The abdomen in fresh specimens has a general bluish aspect, not so noticeable in preserved specimens, besides its color depends evidently in large degree upon its contents. Denny says "grayish-white or ochraceous gray," which would apply well to preserved specimens, but his plate shows it a blue-gray. Harker says brownish gray. It appears to us that the term used by Mr. Tenney, blue slate-colored, comes quite as near describing the average appearance as any that we have seen. The tubercles at the side of the abdomen and the chitinous plates are chestnut-colored, while the most of the upper surface of the terminal segment in the female and the ventral stripe in the male are black.

The females deposit their eggs on the hair, attaching them very near the skin. Fig. 6, *e* represents one of the eggs, showing its attachment to the hair and the distance from the root of the hair in the specimen drawn. The adhesive substance evidently invests the egg during oviposition and is touched to the hair, the egg then slightly drawn along so as to leave the glue-like mass to form a firm union around the hair and to the egg. The egg is elongate-oval, tapering at the lower end, and having a cap-like covering at the upper end. The surface is set with very minute points just visible under an inch objective, but showing clearly with a power of 300 diameters. At the surface no connection is to be seen between different points, but focusing a little below the surface brings into view what appear to be minute threads or channels running from point to point and giving a reticulate appearance to the eggshell. The points can not correspond to the circular bodies represented in Denny's figure (E, Plate XXV, Monog. Anop. Brit.) which have much more the appearance of protoplasmic granules of the egg contents. The shape of the egg in his figure is also entirely different from that of the specimen from which our figure is drawn.

The young louse escapes from the outer or unattached end, whether by pushing off the cap-like portion or by simply pushing through this portion which appears to be thinner than the rest and may be simply membranous, is not, so far as we know, determined. No marked changes, except in size and the development of the chitinous patches, occur from hatching to maturity.

This is one of the most difficult parasites to destroy, and once settled upon an animal should receive prompt and thorough treatment. The main reliance of veterinarians seems to be stavesacre, and this can doubtless be depended upon to accomplish the desired end. Mr. Tenney recommends the seed of common larkspur steeped, and the animal thoroughly washed with the liquid. He says: "I have known one application to destroy every insect and egg; two will suffice if done thoroughly." Of course this and the stavesacre are nearly identical,

both plants belonging to the genus *Delphinium*. Washes of carbolic acid soap or of tobacco infusion are also effectual, but washes of any kind are of course illy adapted to use in midwinter, the time when there is frequently most necessity for treatment. Mercurial ointment, sulphur, or tobacco smoke, kerosene and lard, or kerosene emulsion, road dust, ashes, etc., may be resorted to, according to the circumstances. Infested animals should, if possible, be placed apart from the others, and much trouble may be saved by this precaution.

Experiments with fumigation have shown this to be a method available when other plans are undesirable, though from the equipment necessary, and the fact that it requires some time in application, it may not prove of as general service as the washes.

The method may be said in brief to consist of a tight box-stall just large enough to admit the largest animals to be treated, one end having a close-fitting door to admit the animal, the opposite end a stanchion in which the animal is fastened, and covering the open part of this end, and made to fit tightly around the head just in front of the horns, is a canvas sack open at both ends, the inner one nailed to the stall and the outer with a running cord to draw it down to the animal's head, thus leaving the eyes and nose in open air. An opening at the bottom of one side admits the fumigating substance, sulphur or tobacco, the latter apparently the most effective. In burning this we used a wire screen to spread the tobacco, placing this over a tin trough containing a small quantity of alcohol. It should be burnt, however, with coals or by using a small quantity of kerosene. The time of exposure necessary will vary some with the strength of fumes, but one to two ounces of tobacco and exposure of 20 to 30 minutes was found effective. Pyrethrum might be better even than tobacco.

This species has been said to occur also on horses, but if this is the case it must be in rare instances, and there need be little apprehension of horses becoming infected with it by transmission from cattle with which they may be associated.

THE LONG-NOSED OX-LOUSE.

(*Hæmatopinus vituli* Linn.=*tenuirostris* Burmeister.)

In connection with the preceding species this louse, as already stated, has long been familiar to cattlemen; it has also been known to entomologists for a considerable time, but its history from the entomological side is not entirely clear. It seems to have been first technically described by Linnæus under the name of *Pediculus vituli*, which name has been followed by Fabricius, Berkenhout, Stuart, and Turton, and, with the exception of the change in the generic name, by Stephens, Denny, and English and American authors generally. Nitzsch described it

under the name of *Pediculus oxyrhynchus*, which name was Latinized by Burmeister to *tenuirostris*. This designation has been followed by Giebel and Piaget, but why the earlier name of Linnæus was dropped we fail to discover. It seems more proper to retain the name given by Linnæus.

Denny describes and figures the species and says that it has been found only on the calf. Giebel also figures and describes it, giving a very characteristic figure, though deficient in some details. Piaget admits the species provisionally, but questions it being separable from *eurysternus* from the fact that descriptions have been based only on female specimens or on those in which the sex was not distinguished, and he seems to think it probable that immature specimens of *eurysternus* may have furnished the basis for this form.*

From material in hand there can be no question whatever as to there being a distinct form corresponding with the descriptions above cited, and while there are some details still to be cleared up we propose to show as fully as possible the differences. While our material does not include any specimen that can be recognized as a male, it does include enough specimens of the early stages and females of both this species and the *eurysternus* to entirely set at rest any question as to immature forms of *eurysternus* having been described as *rituli* or *tenuirostris*.

In this species the body is about one-eighth of an inch long and not more than one third of that in width (see Fig. 7). The head is long and slender, the antennæ set near the middle each side; there is but a very slight protuberance behind the antennæ and no eyes visible. The head sets well back into the thorax, forming an acute angle behind; the thorax is longer than wide, and has a distinctly showing spiracle above the second pair of legs; the abdomen is elongate, without chitinous plates and devoid of any tubercles along the sides; the terminal segment is also devoid of black horny band; the brush-like organ on the under side of the abdomen (see Fig. 7) is slender, while the terminal segment is set with numerous rather long hairs.

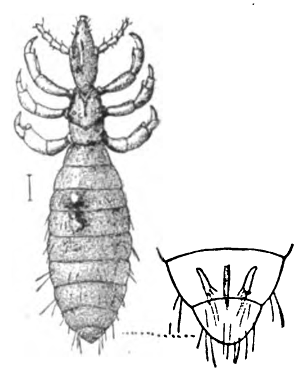

FIG. 7.—*Hæmatopinus vituli*, and under surface of last segments of female, showing brush-like organs. (Original.)

In all of these points it will be observed there is a distinct difference from *eurysternus*. The brush-like organ on under surface of the abdomen, common to females of related species and which is wanting in young specimens of all species, must be taken as distinct evidence of the ma-

* Since the preparation of this section and the figures illustrating the species I have seen the supplement to Piaget's Les Pediculines and find that he now admits this as a good species and gives a figure of the female, without, however, any special details of structure.

turity of the specimens. If, however, there were any doubt on this point a study of the young of *eurysternus* gives equally conclusive testimony. In the very youngest *eurysternus* we have seen the chitinous tubercles along the sides of the abdomen inclosing the spiracles are distinctly to be seen, while the head, though longer proportionately than in adults, is by no means equal in length to that of adult *vituli*. A young *vituli* found, it is true, associated with *eurysternus* shows this elongation of the head still more markedly. In color there is little difference in the two forms, this species having rather duller colors upon the head and thorax. The abdomen of young specimens, when full of blood, appears dark red, but the bluish-gray hue is more prominent in adults. The eggs of this species have not been described and we have not had the good fortune to discover them. The young are even more slender than the adults.

The remedies that are available for the preceding species will prove effectual for this, and it is evidently less difficult to subjugate than that form.

THE BUFFALO LOUSE.

(*Hœmatopinus tuberculatus* Burm.)

This species was described by Burmeister (Gen. Ins.) under the name of *Pediculus tuberculatus*.

It is described in Giebel's Epizoa, p. 46, and described and figured by Piaget (Les Pedic., p. 650, Pl. 53, Fig. 2). It is compared by Giebel with the hog-louse and by Piaget with the *H. eurysternus*, which from his figure it seems most nearly to resemble. According to Piaget this species is probably identical with the *Pediculus* (*H.*) *phthiriopsis* of Gervais, (Apteres, III, 306) from the *Bos cafer* and with the *Pediculus* (*H.*) *buffali* of DeGeer (Mem., VII, 68), in which case the name given by DeGeer should be adopted for the species. Rudow (Zeits f. d. ges Naturw., XXXIV, 167) describes a species under the name of *Hœmatopinus punctatus*, from the *Bos grunniens*, which possibly will be found referable to this same species.

Whether the same species occurs on our American bison is not known, but the unfortunate extermination of this animal renders the question, from a practical standpoint, of little importance. Lucas describes and figures the species in the Annales de la Société Entom. de France (1852, ser. 2, tom. X, p. 531, Pl. 11, No. II) referring it to the species described by Burmeister in 1838 in the "Genera Insectorum." Specimens, he says, occurred in immense numbers on a *Bos bubalus* in the Museum of Natural History.

THE HOG-LOUSE.

(*Hœmatopinus urius* Nitzsch.)

Occasionally this species appears in formidable numbers, since we often hear of swine badly affected with lice, and no other species is known to attack this animal.

Giebel credits this species to Moufet, citing the Theatrum Insector. (1634, 266), while Piaget states that it is cited by Moufet on the authority of Albertus (IV., C. 205), which would carry its recognition back to the thirteenth century. Linnæus described it under the name of *Pediculus suis*, which name has been most commonly followed, but Nitzsch revived the name of *urius* and this name has been followed by Giebel and Piaget. Along with other parasites it received frequent mention by both early and modern writers. Denny speaks of it as rare in England, but common in Ireland. He says (Monog. Anop. Brit., p. 35):

"This species is found in great numbers on swine, but it does not appear so generally spread as might be expected from the dirty habits of the animals. It most frequently occurs on those fresh imported from the sister isle. It was many months before I could obtain a single example. I had applied to both farmers and pig butchers, neither of whom seemed to approve of the idea which I had conceived, that of *their* pigs being *lousy*, but referred me to those of the Emerald Isle as being sure to gratify my wishes (forgetting, I suspect, that the Irish pigs come to this market to meet English buyers). I accordingly visited a colony just arrived, where I most certainly met with a ready supply; but here they were confined almost entirely to lean animals, and wherever I found a pig fat or healthy no game were to be seen."

Most stockbreeders have probably seen instances of its abundance, and from the frequent mention of it in the agricultural papers, it would seem to be quite common throughout the country, and while, perhaps, less generally distributed than the ox-louse, to multiply some times so as to cause much more apparent damage to its host. The fact that they are more commonly found on poor or runty animals should not be taken as evidence that they have a preference for such animals, but rather that the animals upon which they have multiplied rapidly have, in consequence, become emaciated and unhealthy. That they do not increase more rapidly and become a much greater nuisance may be in part because the majority of hogs are sold and slaughtered at a comparatively early age, and with each one slaughtered must perish the parasites which have been supported by it, unless, perchance, an occasional one escape the scalding trough and succeed in finding another host. Of the vast number of hogs shipped to market and slaughtered at the great packing houses, none can bequeath the insects they have nurtured to their followers. The amount of injury and the consequent need of precautionary measures are, therefore, much less for this species than for many others.

This is one of the largest species of the family, full grown individuals measuring a fourth of an inch or more in length. It is of a gray color, with the margins of the head and thorax and most of the abdomen dark. The head is quite long, the sides nearly parallel, with strong eminences just back of the antennæ, which are set on the sides of the head, midway from rostrum to occiput; the legs are lighter with dark

bands at the joints; the spiracles are inclosed by a black chitinous eminence, and there is a broad black band on the last segment, broken near the middle. (See Fig. 8.)

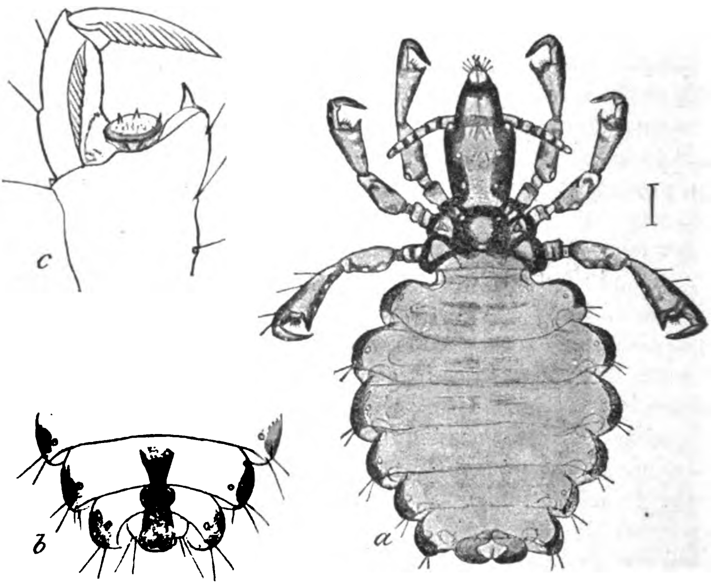

FIG 8.—*Hæmatopinus urius*: *a*, female; *b*, male, ventral view of posterior segments; *c*, leg, showing protractile disk of tibia. (Original.)

The male has the abdomen marked beneath with a large black area extending forward from the end of the terminal segment, so as to occupy the central portion of the last three segments.

There is a curious provision in the feet for strengthening the hold upon the hair, which does not seem to have been hitherto described.

It consists of a circular pad-like organ or disk in the outer portion of the tibia which is received in a conical cavity in the end of the tibia, and which can be forced out so as to press upon the hair held between the claws of the tarsus and the end of the tibia.

Ordinarily, and always in the dead specimens, this is withdrawn so as to appear simply as a part of the end of the tibia, and the spines located on its margin, appear to belong to the tibial rim, but if examined with sufficient magnification when the louse is alive it is easy to observe the extrusion of the organ.

Whether similar organs exist in related species is yet undetermined, but it seems quite probable that they should, since in the specimens examined microscopically we have usually to deal with dead and preserved individuals in which this structure would almost certainly escape notice.

The eggs are one millimeter and a half in length (.06 in.) by three-fourths of a millimeter in width (.03 in.). They are light yellow or dusky

whitish in color, and taper slightly to the point of attachment. The circular lid-like portion is large, occupying nearly all the surface of the free end of the egg. They are attached usually near the base of the hairs.

On account of the thinness of the hair, the application of remedies, where necessary, is quite easy. Washes of tobacco water or dilute carbolic acid, and the application of kerosene in lard, or kerosene emulsion by means of force pump, sulphur, ointment, etc., are recommended. The application of fine dust may be provided for naturally by allowing the hogs a chance to roll in a roadway or any place well supplied with fine dust. Where this is impracticable the dust, ashes, or powdered charcoal may be applied directly to the neck and back of the infested animal. The species is not known to attack any other of the domestic animals, and hence no precautionary measures in this direction are necessary.

THE SUCKING HORSE LOUSE.

(*Haematopinus asini* Linn.—*macrocephalus* Burm.)

Notwithstanding the probable frequent occurrence of this species we have as yet failed to meet with examples. The biting lice from horses have been secured in great numbers, but we have searched in vain for this one.

It is figured by Redi (Exp., Pl. XXII, Fig. 1) and was described by Linnæus under the name of *Pediculus asini*, presumably his specimens being taken from the ass. Later Burmeister described specimens from the horse under the name of *Pediculus macrocephalus*. Denny retains the name given by Linnæus and states that it is common upon the ass, and that he also had specimens from the horse, from which circumstance he suspected Burmeister's *macrocephalus* to be the same. Giebel and Piaget both follow the name of Burmeister, and Piaget separates as a variety the form occurring on the ass, and gives it the name of *colorata*.

It seems hardly probable that it occurs in this country in sufficient numbers to cause much trouble on horses. Possibly examination of mules, asses, or donkeys would show greater abundance from the fact that horses in general are more carefully groomed than their somewhat despised relatives. The size is about the same as that of the ox-louse, but it differs very decidedly in the form of the head, which is long, slender, and the sides of the head nearly parallel, as shown in the figure (Fig. 9), taken from Comstock's Introduction to Entomology.

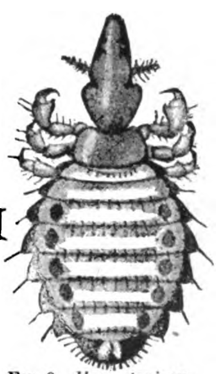

FIG. 9. *Hæmatopinus asini.* (From Comstock.)

Careful grooming may be looked upon as at least favorable to the reduction of numbers in this species. In case they become too numerous the application of a little kerosene to the card or curry comb used in grooming the animals will be

found of value. Where more vigorous treatment is necessary the measures recommended for the ox-louse may be adopted.

SUCKING LICE INFESTING THE RODENTS.

(*Hæmatopinus* sp.)

Belonging to the same genus of suctorial lice as those previously mentioned, we have a number of species common to the smaller mammals, particularly those of the group of gnawing mammals, the *Rodentia*.

These smaller mammals, though perhaps never strictly domesticated, save the rabbit, are very often kept in a semi-domesticated state, either as pets in zoölogical gardens or, in case of rats and mice, quite involuntarily because of our inability to entirely rid ourselves of them. A few notes on the lice infesting them will therefore be of interest here. It is desirable to be able to identify them in case of their accidental occurrence on other mammals, and thus to be able to determine whether, in such cases, we have to deal with a species likely to prove of any trouble.

The common rat (*Mus decumanus*) supports a species, *Hæmatopinus spinulosus*, which with its host must be distributed over most of the world. It has been taken at Ames, Iowa, though in small numbers, and it seems to be rather scarce. It is not recorded heretofore for this country so far as we know, and many animals were examined before finding specimens; a fact in part due, perhaps, to its minuteness.

It is a small species of a light yellow color, the head projecting very little in front of the antennæ and the thorax very short. The mice are said to harbor a distinct species, but there seems to be some doubt as to its being a genuine species.

Hæmatopinus acanthopus occurs on the field mice and has been taken at Ames from a species of *Arvicola*. It resembles the preceding in color and form, but is somewhat larger; the egg presents some peculiarities, which are described in detail in the appendix.

Other species described in European works are the *H. sphærocephalus* on *Sciurus vulgaris*, and *H. læviusculus* on *Spermophilus eversmanni*, and two species, *H. lyriocephalus* and *H. ventricosus*, on rabbit or hare. These have not been met with as yet in this country.

Specimens have been taken from our common flying squirrel, fox squirrel, ground squirrels, and chipmunk, and also from the white-footed mouse and the pocket gopher, which do not appear to have been previously described, and these will be found described in detail in the appended note.

THE ELEPHANT LOUSE.

(*Hæmatomyzus proboscideus* Piaget.)

This louse, infesting the elephant, is about as exceptional in its way as the animal which harbors it. It appears to be of quite recent notice, though it is not unlikely that it has been known in countries

where the elephant has been domesticated for an indefinite length of time.

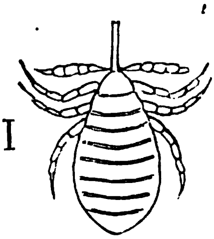

FIG. 10. — *Hæmatomyzus proboscideus*. (After Murray.)

It was described by Piaget (Tijdschr. voor. Ent., 2d series, IV, 254) in 1869, under the name of *Hæmatomyzus elephantis*. The same author, however, in his elaborate monograph, *Les Pediculines*, changes the name to *H. proboscideus*. This louse differs from the others of the family in having a slender prolonged snout extending in front of the head. The antennæ are located at the base of this snout, and according to Murray are lenticular in form. In Piaget's figure, however, they appear of nearly equal thickness throughout. "Color reddish, madder brown, smooth, shining, impunctate." (Murray.)

TECHNICAL DESCRIPTIONS OF NEW SPECIES.

LOUSE OF THE FIELD MOUSE.

(*Hæmatopinus acanthopus* Burm.)

Apparently common on our species of Arvicola, and does not appear to vary in any important particular from the descriptions of European specimens.

DESCRIPTION OF THE EGG.

The egg in this species, unlike those of other forms we have met, is attached to a bundle of hairs instead of to one, our specimen thus having attachment to four hairs, as shown in Fig. 11. This would seem to be an excellent provision where the hair is so fine as in these animals.

The egg is elongate oval, broad, and somewhat truncate at the attached end; the surface is roughened, rugulose, or foveolate appearing squamous in places, and in section showing rounded pits on the surface; the investing substance at base is slightly corrugated. See Fig. 11*e*.

The larva is much shorter and thicker in proportion than the adult, the spiny hairs of the abdomen wanting, but with one or two long slender hairs extending back from the terminal portion.

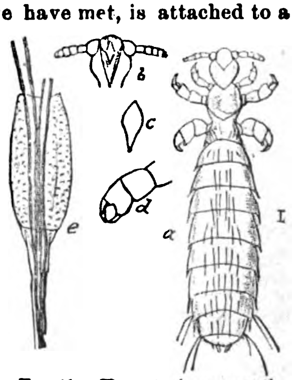

FIG. 11.—*Hæmatopinus acanthopus*: *a*, dorsal view; *b*, head; *c*, sternal plate; *d*, posterior leg; *e*, egg; all enlarged. (Original.)

LOUSE OF THE FLYING SQUIRREL.

(*Hæmatopinus sciuropteri* n. sp.)

Body slender, light yellow, head as broad as long, expanding laterally at the posterior border above and with an acute angle behind; beneath triangular and running back to a sharp angle between the anterior legs, the front projecting very slightly beyond the antennæ, very slightly convex, the rostrum located back of the anterior

border; the trophi plainly visible passing back into the prothorax; the antennæ very large and strong, first joint much the largest, occupying in its attachment half the lateral margin of the head; second joint ordinary, third joint very short, but the anterior portion extending to more than usual length and appearing like a process and bearing a stiff hair and two or three tooth-like spines; the fourth joint attached apparently very near the base of the third on posterior side and of usual length; the fifth joint short, the terminal pit with two or three short hairs; the postero-lateral angles of the head armed with a long stiff hair.

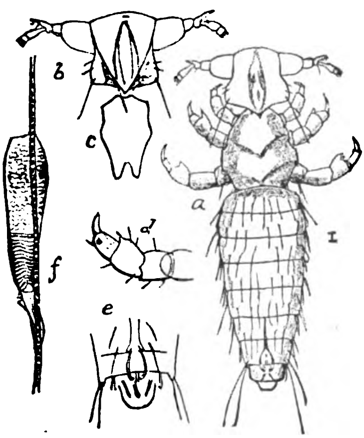

FIG. 12.—*Hæmatopinus sciuropteri*: *a*, male, dorsal view; *b*, head, ventral view; *c*, sternal plate; *d*, leg; *e*, terminal segments; *f*, egg; all enlarged. (Original.)

Thorax widening from before backward, longer than its greatest width, lateral borders irregular, the posterior border concave; the sternal plate is very large, emarginate in front and a large emargination corresponding to each leg, deeply bilobed posteriorly; anterior legs not half the size of the others, claws weak; posterior legs largest. These and second ones provided with strong clasping claws, or terminal joint of tarsus, opposing basal joint of tarsus, which is provided with corrugated plate; tibia at apex internally provided with a short toothed spine.

Abdomen of eight segments, elongate, each segment sparsely set with short, very stiff hairs, those at lateral angles spine-like; penis distinct, of ordinary form. (See Fig. 12.)

Egg elongate ovate, attenuated toward the attachment, the surface with faint reticulations having form of scales; the basal half of the egg has the walls beautifully corrugated. (See Fig. 12.)

	Millimetres.
Length	1.20
Width	.33
Head:	
Length	.27
Width	.26
Thorax:	
Length	.27
Width	.30
Abdomen:	
Length	.73
Width	.33
Antennæ, length	.16
Posterior femur, length	.10
Posterior tibia, length	.10
Egg:	
Length	.80
Width	.18

This species, in the form of the head and the character of the antennæ differs very decidedly from most of the other members of the genus and is readily distinguished by these characters as also by the form of the sternal plate.

One specimen male and one egg taken from different specimens of the flying squirrel *Sciuropterus volucella*, but undoubtedly belonging to the same species. Collected at Ames, Iowa.

LOUSE OF THE FOX SQUIRREL.

(*Hœmatopinus antennatus*, n. sp.)

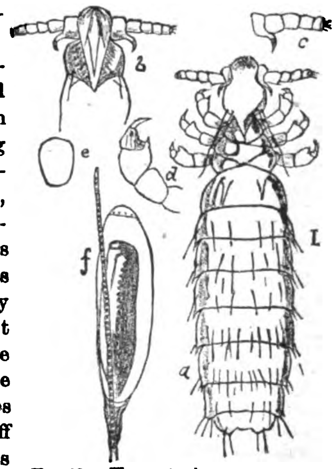

FIG. 13.—*Haematopinus antennatus*: *a*, dorsal view; *b*, head, ventral view; *c*, antenna; *d*, leg; *e*, sternal plate; *f*, egg; all enlarged. (Original.)

Body long and slender, the abdomen proportionately large.

Female.—Head narrow and rounded in front, widening decidedly behind the antennæ, deeply hollowed beneath the lateral margin, the postero-lateral margin sub acute, bearing a short spine-like hair and a long stiff hair, the posterior border with an acute angle behind; beneath broadly keeled, keel behind narrow, expanding in front to width of head between the antennæ. Antennæ very different from other members of the genus; the first joint large with a short process on the posterior border bearing a sharp inwardly curved tooth; other joints ordinary, second joint longest. Thorax short, widest behind, sternal plate ovate, broadest in front, legs as with allied forms, the posterior pair strongest. Abdomen long, lateral angles produced, bearing a short spine or tooth, a short stiff hair and a long hair; a tuft of hairs on lateral angles of the eighth segment. Egg elongate ovate, surface smooth throughout except at the cap, which is strongly convex and has a row of perforations near the attachment to the body of the shell.

	Millimetres.
Length	1.55 to 1.65
Width	.50
Head:	
Length	.35
Width	.20
Thorax:	
Length	.13
Width	.22
Abdomen:	
Length	1.20
Width	.50
Antennæ, length	.20
Egg:	
Length	.73
Width	.28

This species is at once distinguished from all others, known by the peculiar structure of the antennæ, no other species described possessing the process and curved tooth of the basal joint. In form of head it approaches *acanthopus*, but is larger than that species and has the sternal plate of different forms. The egg is longer, more attenuated in form at base, and devoid of the surface markings characteristic of that species. Collected from a fox squirrel, *Sciurus cinereus* var. *ludovicianus*, at Ames, Iowa.

LOUSE OF THE WHITE FOOTED MOUSE.

(*Hæmatopinus hesperomydis*, n. sp.)

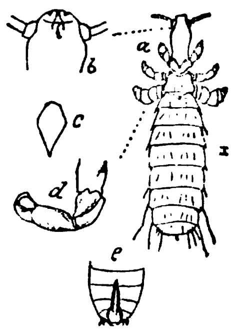

FIG. 14. *Hæmatopinus hesperomydis* — *a*, dorsal view; *b*, head; *c*, sternal plate; *d*, posterior leg; *e*, terminal segments, male; all enlarged. (Original.)

Body elongate, general color golden yellow.

Female.—Head subquadrate, rounded in front, a concavity for the rostrum, obtusely angulated on the posterior border; antennæ set near the front; first joint large, short; second longest, the rest nearly equal; fourth with a small tooth on the posterior border, terminal pit with several short hairs. Thorax shorter than the head, small, sternal plate cuneiform, obtusely angular, irregularly or obliquely truncate in front and sharply pointed behind; anterior legs small and weak, the middle ones somewhat larger, the posterior pair much the largest, flattened; terminal joint of tarsus very broad and curved, opposing basal joint of tarsus and meeting tibial spur in such manner that the three form almost a complete cylinder; abdomen oval elongate, sparsely set with short spiny hairs, one or two long hairs at lateral angles of sixth and seventh segments.

Male, more slender, head longer and tapering somewhat toward the front. See Fig. 14.

Egg, as seen in the body of adult female specimen, is elongate oval.

	Millimetres.
Length	.75 to .90
Width	.28 to .33
Head:	
Length	.13 to .16
Width	.10
Thorax:	
Length	.10
Width	.13 to .15
Abdomen:	
Length	.50 to .60
Width	.28 to .33

The species approaches the *acanthopus*, resembling it in the form of the sternal plate, the character of the legs, and the general form of the body. It differs, however, in having the sternal plate less narrowed posteriorly, more obtuse, or even truncated in front; more decidedly still in the form of the head, which is longer and less excavated for the insertion of the antennæ. It is also smaller, and the egg, if we may judge by what we can see through the walls of the female, is more elongated.

It has been collected from the white-footed or deer mouse, *Hesperomys leucopus*, at Ames, Iowa.

LOUSE OF THE GROUND SQUIRRELS AND CHIPMUNK.

(*Hæmatopinus suturalis*, n. sp.)

Body short, broad; color, golden yellow.

Head oval, rounded and deflected in front; a large chitinous ring inclosing the base of the rostrum; a very distinct transverse suture behind the antennæ; sides slightly convex; lateral angles obtuse, without hairs; posterior angle acute, and passing well back upon the thorax; antennæ simple, located anterior to the middle of the sides; joints nearly equal in size. Thorax short, convex at sides, widest behind, sternal plate nearly circular, surface roughened; anterior and middle legs slender and nearly equal in size; claws slender and sharp; posterior legs very thick, claw strong and broad. Abdomen short, ovate, broadest near the front, sutures inconspicuous, hairs long; some of those on sides and posteriorly very long. Males and females are very similar, and distinguishable only by genital armature of male.

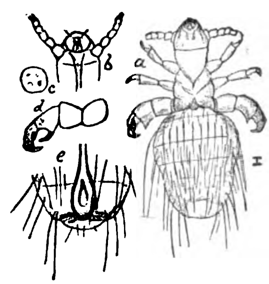

FIG. 15. *Hæmatopinus suturalis*: *a*, dorsal view; *b*, head; *c*, sternal plate; *d*, posterior leg; *e*, terminal segments, male; all enlarged. (Original.)

	Millimetres.
Length	.75 to .80
Width	.35 to .40
Head:	
Length	.27
Width	.13
Thorax:	
Length	.13
Width	.18
Abdomen:	
Length	45 to .48
Width	.35 to .40

This species is particularly well marked by the general form of the body and especially by the conspicuous transverse suture back of the antennæ. It differs further from most of the species in the genus in having both the anterior and middle legs slender and of nearly the same size, while the posterior legs alone are especially modified as clasping organs.

Although we have not seen Middendorf's description and figure of *H. læviusculus* from *Spermophilus eversmanni*, there can be scarcely a possibility of this being identical with it, since this differs in almost every particular as compared with the diagnoses of that species given by Giebel and by Piaget. We therefore describe it without hesitation as a new species.

It has been found plentiful on *Spermophilus franklini* and *S. 13-lineatus* at Ames, Iowa. An immature specimen from *Tamias striatus* presents the characters of the species so plainly that there can be little doubt that it is identical.

HÆMATOPINOIDES.

Nov. Gen.

Antennæ composed of three joints, terminal joint deeply excavated on the posterior side; abdominal segments at lateral margins broadly chitinous with a strong tubercle and a semicircular plate above and below lapping over the chitinous portion of the succeeding segment.

SUCKING LOUSE OF THE POCKET GOPHER.

(*Hæmatopinoides squamosus*, n. sp.)

Body oblong, broadly flattened; general color, dark yellowish. Head small, longer than broad, narrowly rounded in front, widening behind the antennæ; lateral angles rounded, posterior margin acutely pointed beneath, with two large hairs set between the bases of the antennæ and directed outward; antennæ composed of but three joints, these being nearly equal in size, the first short, stout; the third longest and with a deep excavation on the posterior side. Thorax small, broader than long, margin irregular, sternal plate obtusely angled in front; lateral margins parallel, passing by obtuse angles into an acutely angled posterior extremity; immediately back of the sternal plate are two irregularly triangular, chitinous plates, occupying the region of the metathorax and extending each side so that their bases reach to the bases of the coxæ. Anterior and middle legs of nearly the same size, hind legs larger, stouter, and better fitted for clasping. Abdomen large, oblong or elliptical, broadening very rapidly at base and terminating abruptly; lateral margins of segments broadly chitinous, a strong tubercle directed posteriorly and a semicircular plate above and below lapping over the chitinous portion of the succeeding segment, spiracle located at middle of lateral margin; median portion membranous, appearing minutely squamous. The sutures of the segments faintly indicated, a few long hairs scattered over the median portion of the dorsal surface, two hairs on each lateral tubercle, these much elongated on segments 6 an 7; the eighth with a tuft of hairs.

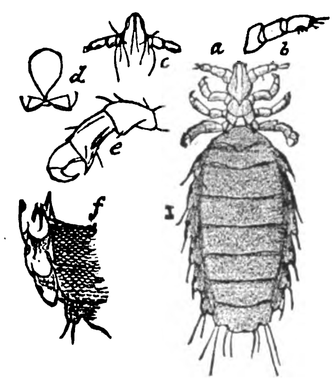

FIG. 16.—*Hæmatopinoides squamosus*: *a*, female dorsal view; *b*, antenna; *c*, head; *d*, sternal plate; *e*, posterior leg; *f*, border of abdomen; all enlarged. (Original.)

	Millimetres.
Length	1.20
Width	.50
Head:	
Length	.27
Width	.13
Thorax:	
Length	.13
Width	.20
Abdomen:	
Length	.87
Width	.50
Antennæ, length	.10

This species departs so remarkably from others of the group that it seems necessary to create for it a new genus. The most important characters and those which seem of generic value are the three-jointed antennæ and the semicircular plates on margins of the abdomen. The sternal structure is also different. In general aspect, however, it approaches the genus Hæmatopinus.

Two specimens, both females, collected from the pocket or pouched gopher, *Geomys bursarius*, at Ames, Iowa.

ORDER PSEUDONEUROPTERA.

SUBORDER MALLOPHAGA.

This group embraces all the biting lice infesting birds and mammals. They are very distinct, indeed, from the preceding group, though frequently placed with them under such unnatural divisions as *Anoplura*, *Pediculines*, etc.

The bodies are usually hard and horny and much flattened. They possess mandibulate mouth parts adapted to cutting and biting the hairs, feathers, epidermal scales, or excretions on the bodies of their hosts. They are said also to have a suctorial organ by means of which they may at times draw blood from the host animal. The mandibles are situated in most forms underneath the head and near the center, the clypeus projecting and forming the most anterior portion of the head. The labrum is present and the maxillary palpi are prominent in a part of the order. The eyes when visible are located back of the antennæ. The antennæ are five-jointed except in *Trichodectes*. The thorax is generally narrow and frequently but two divisions are apparent. The legs are adapted to clasping (*Philopteridæ*) or to running (*Liotheidæ*), the tarsi in the first case being short and fitted for clasping against the tibiæ, and in the second case being long and provided with two claws well adapted to running. The members of the first division occur on both mammals and birds, those of the second, except *Gyropus*, are limited to birds. Wings are entirely wanting and the abdomen contains nine or ten segments and is usually oval in shape.

In life history this group agrees with the preceding. The eggs are glued to the hairs or feathers of the host animal and open with a circular cap or lid at the free end. The larvæ are less flattened, shorter in proportion, and without the hardened parts common to the adults covering a part or all of the surface. The length of life and rapidity of multiplication has not been determined for any species so far as we know, and the habits of the insects make any such determination a matter of great difficulty.

The effect of these upon the host animal may be less important than that of the suctorial lice, but judging from cases where serious results follow from the efforts of the animals to rid themselves, and from the known irritation due to the crawling of anything among hairs and feathers, it can not be doubted that they cause much inconvenience to the creatures which become their involuntary supporters.

The order may easily be separated into two families upon characters a part of which have already been mentioned, namely, the structure of the mouth parts and the feet. The latter, which is the most easily observed, can easily be told from the mode of locomotion, the members of the first group being incapable of rapid movement but well adapted to clinging to the hairs or feathers, the latter running freely and swiftly but having less power to clasp.

FAMILY PHILOPTERIDÆ.

Infesting horses, cattle, sheep, dogs, cats, chickens, turkeys, pigeons, ducks, etc.

The members of this family have the mouth parts on the under side of the head. Mandibles strong; maxillæ wanting; tarsi short, of one or two joints, the claw meeting a tooth at the apex of the tibia; mesothorax apparently wanting; abdomen having nine segments.

The group is a large one, the species being so numerous that scarcely a bird but harbors one, and sometimes several, species of this family.

The genera are, for the most part, easily separated; *Docophorus*, by the presence of a movable appendage (trabecula) in front of the antennæ; *Nirmus*, by the presence of an immovable tooth in front of the antennæ and the generally entire terminal segment of the abdomen of the female. *Goniocotes* and *Goniodes* are robust forms, usually with large heads strongly curved in front; they differ by the former having simple antennæ in both sexes, while in the latter they are modified in the male. The former are also usually much the smaller. In *Lipeurus* the body is generally long and slender, the antennæ of the males large and often with a complicated structure, while the terminal segment of the female is bilobed. The species of *Ornithobius* are white or transparent and especially characterized by having sharp curved appendages meeting in front of the clypeus. *Trichodectes* is at once known by the three-jointed antennæ. Other genera of the family do not contain species infesting domestic animals, and hence need not be noticed here.

LOUSE OF DUCKS AND GEESE.

(*Docophorus icterodes* Nitzsch.)

This species has been recorded from so many different members of the order of birds containing the ducks and geese that it may be considered as common to the order. It was described by Nitzsch in 1818 and has been mentioned by most writers on parasites since that time. It is about 1 millimetre in length, and has the head and thorax of a bright reddish color with darker bands. The abdomen is white in the center, with broad, dark reddish, horny bands at the sides, with a darker spot at the margin.

THE LITTLE RED SWAN-LOUSE.

(*Docophorus cygni* Denny.)

Notwithstanding the apparent abundance of this species it does not appear to have been described before 1842, when it was described and figured by Denny (Monog. Anop. Brit., p. 95, Pl. 1, Fig. 1), but according to this author it was figured by Redi (Exper., Pl. IX, fig. inf.), which would carry its recognition back 200 years. It is common on both the wild and domesticated swans, and Denny states that he has received it from the bean goose.

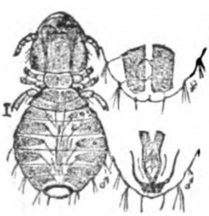

FIG. 17.—*Docophorus cygni*. (Original.)

It is a millimetre in length, of a robust form, the head decidedly rounded in front, except at the extreme tip, where it is slightly excavated. In color the head, thorax, and legs are bright reddish brown, while the abdomen is white in the center and dark brown at the sides, the brown occupying hard plate-like portions at the side of each segment.

The form and the distribution of these plates are shown in the accompanying figure.

CHICKEN LOUSE.

(*Goniocotes hologaster* Nitzsch.)

This common species of the domestic fowl was recognized by DeGeer and by Nitzsch. It has been generally confused with another form, or rather another larger and perhaps more common form has been generally accepted by English and American writers as the *hologaster*, this being due to the description and figure given by Denny, who does not seem to have seen the true *hologaster*, but described for it, according to Piaget, an immature specimen of the larger species since described as *Goniocotes abdominalis* Piaget.

The *hologaster* is only about one millimetre in length, whereas the *abdominalis*, or Denny's *hologaster*, is about three millimetres. In general form the species is somewhat similar, the *hologaster* being less constricted at the thorax and more regularly tapering to the end of the abdomen. The head is more nearly quadrate; the abdomen not so conspicuously marked, the incurved margins of the segments not extending so decidedly upon the disk and presenting the distinct lines seen as a border to the fasciæ in *abdominalis*.

CHICKEN LOUSE.

(*Goniocotes abdominalis* Piaget.)

This is probably fully as common as the preceding species. As already stated, it is the form which has been commonly referred to in

English and American works as the *Goniocotes hologaster*, which doubtless accounts for its not having been described until quite recently.

FIG. 18.—*Goniocotes abdominalis*-*hologaster* of Denny. (After Denny).

It is a large, conspicuous species, about 3 millimetres in length, quite broad, the head nearly circular in front and constricted behind, the thorax small, the abdomen widening to near the end and terminating abruptly. The head, thorax, and legs are yellowish, with dark margins and spots; the abdominal segments bear lateral whitish fasciæ bordered with black.

It appears to be much less common than some other species of chicken lice, notably *Menopon pallidum* and *Lipeurus variabilis*.

PIGEON LOUSE.

(*Goniocotes compar* Nitzsch.)

A species which has been familiar for a long time and generally common, along with other lice, on domestic pigeons. It is a rather small-sized species, a little more than a millimetre in length. The head is rounded in front, narrower between the antennæ, broadest near the posterior margin. The thorax is narrow, the abdomen in the male broadest near the posterior end and squarish behind, in the female more regular and broadest near the middle. It is whitish, with a rather broad brownish margin, from which prolongations extend inward upon the sutures.

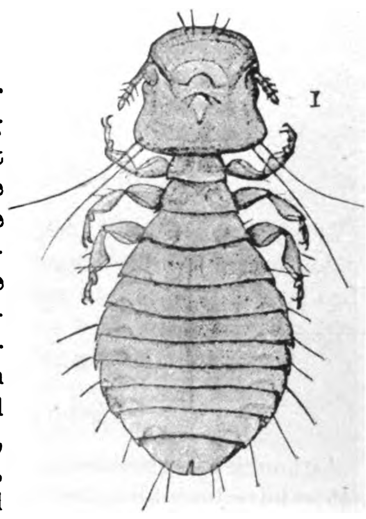

FIG. 19.—*Goniocotes compar*. (Original.)

THE PEACOCK GONIOCOTES.

(*Goniocotes rectangulatus* Nitzsch.)

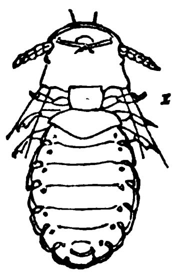

FIG. 20.—*Goniocotes rectangulatus*. (After Piaget.)

This species which shares with the *Goniodes falcicornis* the hospitality of the peacock, was first described by Nitzsch (Germar's Mag., III, 294). It is a small species, about the size of the *hologaster*, which it resembles quite closely. The head is squarish, somewhat rounded in front, while the thorax and abdomen are short and oval.

While less noticeable than the larger species associated with it, it is probably no less abundant.

BURNETT'S GONIOCOTES.

(*Goniocotes burnettii* Packard.)

A species described by Dr. A. S. Packard (Am. Nat. vol. IV, p. 94) is apparently much less common than some of the other species common to the sadly infested barnyard fowl. According to Dr. Packard's description it differs from the *G. hologaster* of Europe, which lives on the same bird, in the short second joint of the antennæ, which are also stouter, and in the long head, the clypeus being much longer and more acutely rounded, while the head is less hollowed out at the insertion of the antennæ. The abdomen is oval and one-half as wide as long, with transverse, broad, irregular bands along the edges of the segments. The mandibles are short and straight, two-toothed. The body is slightly yellowish and variously streaked and banded with pitchy black.

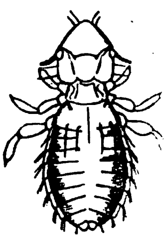

FIG. 21.—*Goniocotes burnettii* Pack. (After Packard.)

GONIOCOTES OF THE PHEASANT.

(*Goniocotes chrysocephalus* Giebel.)

This parasite of the pheasant was first described by Giebel in 1866 under the name of *Goniocotes colchici* which he afterward changed to the above. It is said to resemble the *hologaster* which affects the domestic fowl.

THE CHICKEN GONIODES.

(*Goniodes dissimilis* Nitzsch.)

Although this species has been known for a considerable time, it seems not to have been abundant enough to receive frequent notice.

Denny says: "I suspect this species of being of rare occurrence, as the only specimen which I have examined was communicated by Mr. Thompson from Belfast, and that being a female, I am precluded from describing the characteristics of the male."

It is a large species, 2 to 2½ millimetres in length, and Denny describes it as tawny in color, smooth, shining, and pubescent, with large subquadrate head, a short transverse prothorax, and a large abdomen with the side markings confluent, and the sutures with deep chestnut bands. It has not as yet been recorded for this country that we are aware of, though in all probability it occurs here as well as in Europe.

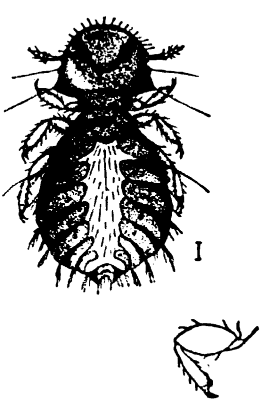

FIG. 22.—*Goniodes dissimilis*. (After Denny.)

LOUSE OF THE GUINEA FOWL.

(*Goniodes numidianus* Denny.)

We have only the record given by Denny (Monog. Anop. Brit., p. 163, Pl. XIII, Fig. 7) as authority for this species. His diagnosis of the species is as follows: "Pale straw-yellow, shining and smooth, margined with black; head suborbicular; abdomen acuminate, with pitchy brown, interrupted transverse bands." He states that "the only specimens of this species I have seen are two males, which I took from off a pintado (*Numida meleagris*)." We have not had the opportunity to search for this species and can not say whether any effort has been made in this country to obtain parasites from the guinea fowl. It is most likely that a careful examination of a number of the fowls would furnish examples of this species and possibly still others not yet recognized.

THE PIGEON GONIODES.

(*Goniodes damicornis* Nitzsch.)

According to Giebel this species was first described by Nitzsch, and his reference is "Zeitschrift f. ges. Naturwiss., 1866, XVII 119." It is a rather large species, a little more than two millimetres in length and of a bright-brown color. The head is very much rounded in front and strongly angular behind. It occurs only on pigeons, but upon these appears to be rather common, though not yet met with in our own collecting.

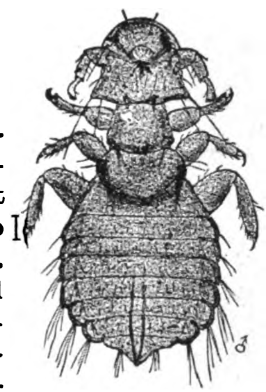

FIG. 23.—*Goniodes damicornis.* (Original.)

THE LITTLE PIGEON GONIODES.

(*Goniodes minor* Piaget.)

Piaget (Les Pediculines, p. 256) has described as a distinct species, under the above name, a form quite similar to the preceding but smaller and presenting some differences of the antennæ and form of the head. According to this author it is found on the domestic pigeons and also on *Columba tigrina*, *C. risoria*, and *C. bitorquata*. It has not to our knowledge been recorded in this country as yet, but is likely to be found along with the other forms.

LOUSE OF TURKEY.

(*Goniodes stylifer* Nitzsch.)

Nitzsch describes this species in Germar's Magazine (III, 294), and it has been frequently mentioned since that time. It was also described by Schrank under the name of *Pediculus meleagris* (Faun. Ins. Aust., 504). It is a large species, 3 millimetres or more in length, and quite readily distinguished from other common species by the hind angles of the head, which are extended backward into long styles from the ends of which extend strong bristles. The thorax is angular with a black margin and the abdomen is pale with transverse bands of dark color.

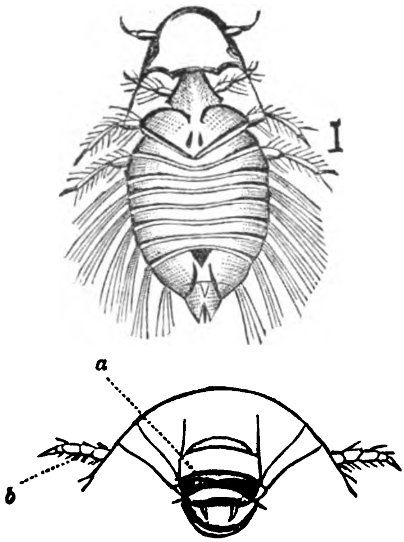

FIG. 24.—*Goniodes stylifer* enlarged: *a*, mouth parts; *b*, antennæ. (From Verrill, after Cuvier.)

The species probably has a distribution equal to that of the turkey itself, and with the other species common to this fowl render it pretty thoroughly infested.

THE PEACOCK GONIODES.

(*Goniodes falcicornis* Nitzsch.)

This large and common species appears to have been first recorded by Redi, who figured it under the name of *Pulex pavonis*. Since that time it has engaged the attention of Linnæus, Frisch, Olfers, Fabricius, Stephens, Schrank, Nitzsch, Burmeister, Stewart, Panzer, Denny, Giebel, Piaget, and numerous other writers, who have described, figured, and discussed it under one name or another, from which we would infer that it must have been one of the most common and frequently met with of any of the parasites of our domesticated fowls.

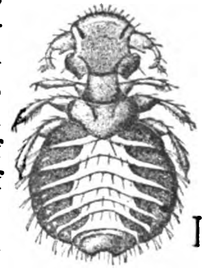

FIG. 25.—*Goniodes falcicornis*. (After Denny.)

It is a large species, 3 to 4 millimetres in length, of a bright reddish yellow color, with a large head the hind angles of which are acute and prominent. The first joint of the antenna in the male is large and bears a prominent tooth. The abdomen is broad, light yellow, with prominent transverse lateral bands extending nearly to the middle line.

THE PHEASANT GONIODES.

(*Goniodes colchicus* Denny.)

This species is not likely to prove of any special interest in this country, and we will simply mention it and repeat the diagnostic description given by Denny:

"Bright chestnut-yellow; head subquadrate, temporal angles obtuse, thorax with a broad ferruginous margin; abdomen pale, yellow-white, nearly orbicular, each segment, excepting the first and last two, with a pitchy black arcuate fascia."

He refers this species to the insect mentioned under the name of *Pediculus phasiani* by Fabricius, with a question as to their identity.

GONIODES GIGAS.

Professor Comstock, in his Introduction to Entomology, page 86, names this as a parasite of the hen, but he states no authority for the species and we are unable to find any other reference to it.

LIPEURUS OF THE CHICKEN AND PHEASANT, ETC.

(*Lipeurus heterographus* Nitzsch.)

This species, first recorded by Nitzsch, would appear from the writings of European naturalists to be rather common, but it has not to our knowledge been taken in this country, a fact which may be due rather to the little attention that has been given to collecting these insects in this country than to their absence.

According to the figures given by Piaget, it differs decidedly from the *variabilis*, with which it is most likely to be confused, in having the head rather narrowed in front instead of inflated, and the body is much stouter.

Besides occurring upon the common domestic fowl, it is said to occur upon pheasants of certain species.

LOUSE OF THE GUINEA FOWL.

(*Lipeurus numidæ*, Denny.)

Denny described this species under the name of *Nirmus numidæ*, but Piaget refers it to the genus *Lipeurus*.

It is characterized by Denny as "livid yellow, shining and smooth; head subpanduriform, lateral margin black; abdomen with two fuscous interrupted dorsal fasciæ."

As he states that he found "two specimens," it would appear not to have occurred in great abundance.

LOUSE OF THE SHELDRAKE.

(*Lipeurus tadornæ* Denny; *Lipeurus lacteus* Giebel.)

Denny described this species from specimens taken from the sheldrake, and cites also a manuscript name of Leach, *Ornithobius tadornæ*, which he assumes to be the same and which applied to specimens in the British Museum. The species was later described by Giebel with the name *lacteus*, though he at the same times quotes Denny's name without stating any reason for the change.

Piaget states that he prefers the name chosen by Giebel to that of *tadornæ* in order to avoid as much as possible the names of birds upon which the parasites have been found. If this principle were carried out it would involve the change of hosts of names applied to members of this group of insects, and as it is directly opposed to the well-established principle of priority we believe the name applied by Denny should be restored.

The insect is characterized by a milky-white color, the surface smooth and shining, the head, thorax, and abdomen with black marginal spots; it is elongate in form and the head heart-shaped.

Professor Comstock cites it as occurring also upon the goose, but upon what authority we are unable to say, as the authorities consulted mention it only as a parasite of the sheldrake.

THE PIGEON LIPEURUS.

(*Lipeurus baculus* Nitzsch.)

This is another of the species that was given a name and figure in the work by Redi more than 200 years ago. It was also described briefly by Linné under the name of *Pediculus columbae*, but since the description by Nitzsch in 1818, under the name of *Lipeurus baculus*, this has been the accepted name, and has been used by nearly all writers since that time.* It is not strange that it attracted the attention of early naturalists, as it occurs in wonderful abundance on almost every pigeon that may be examined, and its striking appearance, due to the extreme slenderness of the body, would at once catch the eye of the observer.

Fig. 26.—*Lipeurus baculus.* (Original.)

It is about 2 millimetres in length, the body very slender; the head and thorax are of a bright reddish-brown color, while the abdomen is rather dusky with a series of patches of a brown color corresponding with the segments of the abdomen.

*Giebel names and describes two species, *bacillus* and *baculus*, referring both to Nitzsch, and placing under *bacillus* the form which all other authors refer to *baculus*, and referring to *baculus* a form not separated by other authors, but which he describes as different from the other form. It seems undesirable to add names without a more decided difference in form, and we agree with Piaget in uniting both under the old name.

So far as known, this species is confined to pigeons, and there seems no danger of their being transmitted to other fowls with which they may associate.

Piaget states that he has found the females astray upon a *Sula alba*, upon a *Totanus glottis* and upon a *Charadrius minor*, only in the last case the appendages of the clypeus wanting; the last segment had the lobes more acute and the dimensions were less.

Denny described, under the names of *Nirmus claviformis*, what appears to be the young of this species, though he gives measurements for males and females, which would seem to indicate that he was able to see the sexual organs. In all the specimens we have examined that agree with his figure and description of this form we have been unable to discover the genital organs, which makes it appear that they are immature, and they are in all cases associated with the *baculus*, with which they seem to agree in all structural characters. The body is shorter, the markings less distinct, and the rudiment of a trabecula is more prominent than in the adults.

It seems best, therefore, at least till well marked males and females can be found, to consider these as immature *baculus*.

Piaget does not discuss this matter, but in his index to the "Les Pediculines" he gives *N. claviformis* as a synonym of *L. baculus*.

THE SQUALID DUCK LOUSE.

(*Lipeurus squalidus* Nitzsch.)

According to Denny, this species was referred to by Fabricius under the name of *Pediculus anatis*, and it seems extremely probable that it was referred to under other names by many of the early writers, since it is so common on many species of ducks that it is hardly possible that it should have been entirely overlooked. The first definite reference to it, however, is the description by Nitzsch in 1818; and, more fortunate than some of the related species, this has been allowed to hold in all subsequent works, and so far as we know there are no synonyms for its specific name.

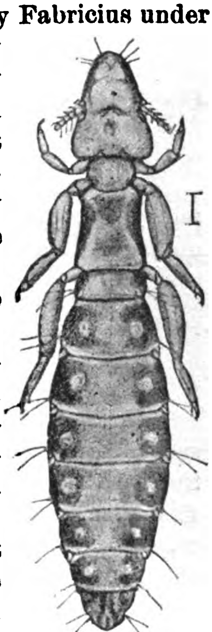

FIG. 27.—*Lipeurus squalidus*. (Original.)

It is a very abundant and common species and occurs on a great many different species of ducks, both wild and domesticated; indeed, so generally does it occur on the different species of the genus *Anas* and related genera that we may almost say that it is common to all species of the family including the ducks.

It is quite characteristic in appearance, and not likely to be confused with other species on the same birds. It is about 4 millimetres (one-sixth inch) in length, elongate in form, and of a light yellowish color, with dark border to the head, thorax, and abdomen.

On the latter this border is broken into a series of quadrate patches corresponding with the segments. The young lack the definite markings of the adults, but have nearly the same general outline of body. The annexed figure will doubtless enable anyone to determine with certainty as to specimens taken from ducks.

(*Lipeurus anseris* Gurlt.)

Under this head is recognized a species which is said to differ from the *anseris* of Linnæus and other authors, which is referred to *jejunis* of Nitzsch. It was described from specimens taken from the domestic goose, but would appear to be rather a rare species since it has not been generally recognized. We insert it upon the authority of Piaget, who seems to consider it as unquestionably distinct from related species, though apparently in doubt as to the real form from which the descriptions were made.

THE LIPEURUS OF THE GOOSE.

(*Lipeurus jejunus* Nitzsch.)

It is generally accepted that Redi had this species in hand as one of the different parasites which he figured, and it has certainly been referred to by Linnæus, Albin, Olfers, and others, but the description by Nitzsch may be taken as the first strictly technical description that would separate it certainly from related forms. Denny records it as taken from the white-fronted goose, the Brent, the wild goose, and the bean goose, and Piaget adds the gray goose, Canada goose, domestic goose, and the *ægypticus*.

It is evident, therefore, that it is generally distributed upon members of the goose family.

We have not had specimens in hand, but it is described as slender, pale yellow-white, with a pitchy margin, the first eight segments of the abdomen with quadrangular bands, and the legs dusky above.

THE TURKEY LOUSE.

(*Lipeurus polytrapezius* Nitzsch.)

This, like the *variabilis*, appears to have been one of the earliest species to receive recognition, as Linnaeus cites Redi (Exper., t. II; fig. 2) with the name *Pediculus accipitris*, while he himself uses the name *Pediculus meleagridis*, and gives a brief description, which probably refers to this species. Authors have quite generally, however, followed the name given by Nitzsch, as above. It has, doubtless, been common wherever this fowl has been kept and is one of the familiar species.

It is of rather large size, 3 to 3½ millimetres (an eighth of an inch) in

length, of an elongated form, having a pale, yellowish white color, and with a black margin around the body. The abdomen is long, and all the segments but the last are marked with a grayish brown trapezoidal spot on each side.

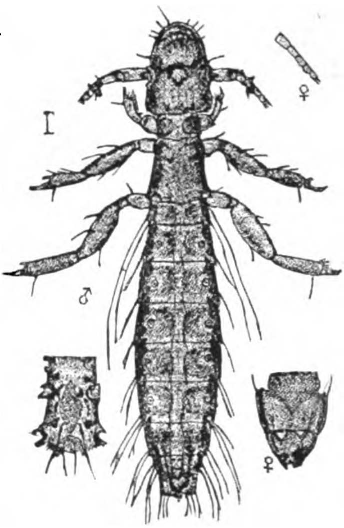

FIG. 28.—*Lipeurus polytrapezius.* (After Piaget.)

According to Denny, "their mode of progression is rather singular, as well as rapid. They slide as it were sideways extremely quick from one side of the fiber of a feather to the other, and move equally well in a forward or retrograde direction, which, together with their flat polished bodies, renders them extremely difficult to catch or hold. I have observed that where two or more genera infest one bird, they have each their favorite localities; for, while the *Goniodes stylifer* will be found on the breast and neck of the bird, the *Lipeurus polytrapezius* will be congregated in numbers on the webs and shafts of the primary wing feathers."

THE VARIABLE CHICKEN-LOUSE.

(*Lipeurus variabilis* Nitzsch.)

This species appears to have been recorded as early as 1668 by Redi, later by Frisch, unless these both refer to *Menopon pallidum*, and to have received a brief description by Linnæus (*Fauna Suecica*, No. 1960) under the name of *Pediculus caponis*. The name by which it is now universally known, however, was given with description by Nitzsch in 1818. (Germar's Mag., III, 292.) While no very extensive literature seems to have accumulated in reference to this particular species, it is of course included in the many articles referring to poultry lice in general. It does not seem, however, to be so abundant as some of the other species infesting the common domestic fowl.

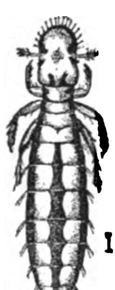

FIG. 29. *Lipeurus variabilis.* (After Denny.)

It is about 2 millimetres (one-twelfth of an inch) in length, the body elongated, of a whitish color, and smooth and shining. The margins of the body are black; the head is large, rounded on the anterior margin, and the whole appearance is sufficiently distinct from any of the species infesting the chicken, so that, with the aid of the figure, there can be no difficulty in distinguishing it at a glance. Denny says: "Common on the domestic fowl, preferring the primary and secondary feathers of the wings, among the webs of which they move with great celerity."

THE WHITE SWAN LOUSE.

(*Ornithobius cygni* Denny; *Ornithobius bucephalus* Giebel.)

This large and handsome species was quite certainly recognized by Redi and figured by him and has received frequent mention since. It is a conspicuous species and appears to occur in great abundance on different species of swans, so that it is readily obtained. It has been recorded as occurring on the domestic and wild swan of the old world as well as the *musicus* and *Bewickii*, and we have taken it in great abundance from the common swan of this country, probably the Trumpeter Swan.

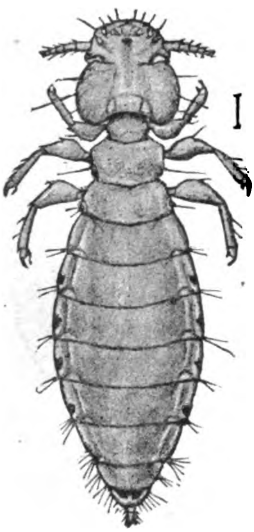

FIG. 30.—*Ornithobius cygni.* (Original.)

The body in this species is whitish, but so transparent that all the internal organs are easily seen through the body walls. There are black points at the outer hind margins of about four of the abdominal segments, as shown in the figure, and the last segment is dusky or nearly black. It is 4 millimetres long (one-sixth of an inch) and the body rather slender and decidedly flattened. Altogether this species seems to be almost as beautiful and as graceful in its movements as the bird which harbors it. Some of the specimens we have secured appear to contain blood, and while these parasites are not supposed to extract blood from their hosts it is possible that they may at times burrow deep enough to secure access to the capillaries or feed upon blood that may have exuded from wounds upon the surface of the body of the bird.

THE LOUSE OF THE CAT.

(*Trichodectes subrostratus* Nitzsch.)

While it is possible that this parasite was referred to by Otto Fabricius about the year 1780 under the name of *Pediculus canis*, the first certain reference to it appears to have been the description by Nitzsch in 1818. Since that time it has been referred to by nearly all writers on the common parasites of animals, but so far as we know there has been no special description of the different stages, and we must assume that there is no important departure from the habits of species that are more thoroughly known.

FIG. 31.—*Trichodectes subrostratus.* (Original.)

It is a little more than a millimetre in length and has much the appearance of the species occurring on other domestic animals, but is distinguished particularly by the form of the head, which is quite pointed, and the under part of the

front of the head is hollowed out in a furrow about the size of a hair. The insect will often be found adhering by the mouth parts with a hair so closely held in this groove that it is somewhat difficult to tell where the hair begins as separate from the insect.

There is no record that we have seen that indicates its presence on any other animal than the domestic cat, and, judging by our own observation, it is only occasionally that cats become infested with it. When they do the usual remedies may be administered, especially a washing with kerosene emulsion, after which the animal should be allowed to dry in a warm place, as the fur is so fine that they dry slowly.

THE BITING LOUSE OF THE DOG.

(*Trichodectes latus* Nitzsch.)

Something over a century ago DeGeer mentioned a species of parasite on the dog under the name of *Ricinus canis*, which probably referred to this species, and another mention by Olfers under the name of *Pediculus setosus* probably preceded the description by Nitzsch under the name which the insect has borne since 1818.

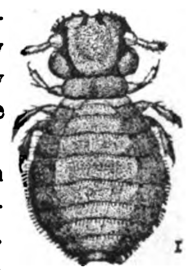

FIG. 32 —*Trichodectes latus*. (After Denny.)

Probably every one who has had much to do with dogs is aware to what an extent this parasite may multiply and how troublesome it is to this friend of man. It is generally believed that the lice are more troublesome to puppies than to old dogs, and it is not at all unlikely that the insects migrate when possible from older to younger animals.

In color this species agrees pretty closely with the other species and it is of about the same length as the cat louse, a little more than 1 millimetre, but it is much broader in proportion, being more than half as wide as long, and the head is short and the front but slightly curved.

THE LOUSE OF THE BEAR.

(*Trichodectes pinguis* Nitzsch.)

Inasmuch as the common brown bear has been to a considerable extent domesticated, and indeed furnishes a means of support to a certain class of people, it seems proper to introduce mention of its common parasite here. The species was described by Nitzsch, and apparently later authors have done little more than quote his description. To what an extent bruin suffers from the company of his guests we are not aware, but they probably multiply upon him as on other animals and cause him the same amount of annoyance.

It is described as characterized by the form of the head, which is subquadrangular. It is nearly 2 millimetres in length.

THE LOUSE OF THE LLAMA.

(*Trichodectes breviceps* Rudow.)

In some parts of South America the llama is a very important domestic animal, and consequently this parasite has a place with the other species included in this work.

This species was described by Rudow in 1866, but as we have not seen specimens we must leave it with the mere mention. It is said to be one millimetre in length and doubtless agrees closely with the other species of the genus in appearance.

THE LOUSE OF THE GOAT.

(*Trichodectes climax* Nitzsch.)

Since this species was described by Nitzsch in the early part of the present century, it does not seem to have received very frequent notice and Denny does not appear to have found it in England. We have as yet not found it in this country, and though it doubtless occurs occasionally among the goats kept here would seem to be rather rare.

It is described as having the head wider than long, quadrangular in shape, and the body in the female nearly two-thirds as wide as long, the length being about 1½ millimetres.

The *Trichodectes capræ* of Gurlt is considered by Piaget as identical with *climax*, while the *Tr. capræ* of Packard is not mentioned by him, but Professor Verrill has expressed the opinion that it is equivalent to *limbatus*, mention of which follows. It may be stated here, however, that the figure given by Packard agrees well with Piaget's figure of *climax*. It may be that all of these are but varieties of one species.

(*Trichodectes limbatus* Gervais.)

This species is referred to the Angora Goat, and is recognized as a distinct species by Giebel, Piaget, and others. It is the species to which Professor Verrill thinks Dr. Packard's *capræ* belongs. Dr. Packard does not state upon which species of goat he found his specimens, but it is probable that they were from the common species, and if so, and inasmuch as his figure agrees fairly well with *climax*, it would seem as likely to belong there.

In a recent bulletin from the Bureau of Animal Industry, Dr. Cooper Curtice describes these forms and endeavors to establish their specific identity. The principal points urged are a proportional difference in size between males and females, a difference in markings, and difference in size of eggs, but these are all variable and the differences, as shown in the excellent figures accompanying the report, are so slight that we are the more impressed with the view that they are the same, and unless it be shown that they do not interbreed nor survive if changed from one host to the other we should be inclined to use the two names as synonyms,

THE LOUSE OF THE SHEEP.

(*Trichodectes sphærocephalus* Nitzsch.)

Redi is credited with the recognition of this species, and following him Linnæus described it under the name of *Pediculus ovis*, and later still it was described in detail under the name given above. Denny's reference to it would indicate it as rare in England and we have not met it here. If it is of rare occurrence it may be considered as fortunate, for, if abundant, it would be rather difficult to contend with on account of the long wool of the host.

FIG. 33.—*Trichodectes sphærocephalus*. (After Denny.)

The name indicates its characteristic feature, namely, the rounded head. The color agrees closely with the related species.

Where it occurs it would be the best plan to pay close attention to destroying them at the time of clipping the sheep even if they are but few in number, as at any other time the labor of making thorough applications for them is greatly increased.

THE BITING LICE OF HORSES, MULES, ASSES, ETC.

(*Trichodectes equi* of Authors.)

The original reference by Linnæus to the lice of horses and asses under the name of *Pediculus equi* most certainly refers to the common *Trichodectes* infesting these animals, but Piaget has reached the conclusion that this reference is to the form subsequently described by Giebel as *Trichodectes pilosus*, and that the form described by Denny as *equi*, and which has since almost universally been treated as the Linnæan species, was in reality a different insect from that described by Linnæus under the same name. He therefore describes this form under the name of *parumpilosus*. It is certainly somewhat confusing to be obliged to drop the familiar designation for so common a species, and were it not that this conclusion has been reached by one who is probably the highest living authority regarding these insects we should hesitate to introduce the change. The figures given by Piaget, however, leave no question that there is a decided difference between *pilosus* and *parumpilosus*, and it is equally certain that our common species belongs to the latter form; so, if there is no question as to Linnæus having the form *pilosus* in hand, we certainly have no right on technical grounds to apply the term *equi* to our common form. We will therefore introduce descriptions and comparisons of the two forms and adopt, for the present at least, and on the authority of Piaget, the names given in his "Les Pediculines."

(*Trichodectes pilosus* Giebel.)

This, according to Piaget, is the form originally designated by Linnæus as *equi*, and which, if that is correct, was the basis for a name

which has been widely used to designate the biting lice of the members of the horse family. The original reference dates back considerably more than a century, and doubtless the insect was familiar many centuries before that, as the horse and ass have been too familiar as domestic animals to allow of the parasites common to them escaping entirely the notice of man.

According to Piaget this occurs upon both the ass and the horse, while the following species he has found only on the horse.

We have not been fortunate enough to secure examples of this form, though we have the other in great abundance, so we are compelled in describing to depend upon the excellent description and figures of Piaget, the latter being reproduced here for comparison. The head in this form is shorter and less rounded in front, that of the male being still less rounded than the female, while the abdomen is more slender and tapering. The transverse bands are also represented as less conspicuous. Perhaps the most striking point, however, is the position of the antennæ, which stand well forward on the head, so that the front border of the head and base of the antennæ are nearly in line.

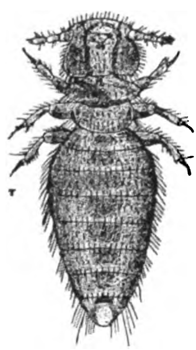

FIG. 34.—*Trichodectes pilosus*. (After Piaget.)

The habits of the species and the remedies applicable to it are naturally identical with those of the other related species.

(*Trichodectes parumpilosus* Piaget.)

While it does not seem possible that all the writers previous to Denny should have overlooked this form, which appears to be the more common one, at least on the horse, it may be true that Denny was the first to give it a thorough description and careful drawing. He speaks of it as common on the horse and ass, but Piaget says he has never found it on the ass and there is of course a possibility that Denny did not distinguish between this and the preceding species.

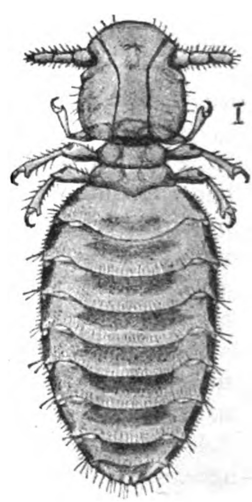

FIG. 35.—*Trichodectes parumpilosus*. (Original.)

In this species the head is decidedly rounded in front, the antennæ inserted well back, so that the head forms a full semicircle in front of the base of the antennæ. The abdomen is more slender and tapering than in *scalaris*, but less so than in *pilosus*, as shown in Piaget's figures. The color is much the same as in the allied species, the head, thorax, and legs being a bright reddish brown or chestnut and the abdomen of a dusky yellowish color, with about eight transverse dusky bands occupying the central or anterior portions of the segments and extending from the middle line a little more than half way to the mar-

gin. They are hardly as conspicuous as in *scalaris* and apparently rather longer and more conspicuous than in *pilosus*.*

Piaget describes two varieties of this species, one from the Burchell's Zebra (*Equus burchelli*) which he calls var. *ocellata* on account of a series of eye-like uncolored spots on the abdomen, and the other from the small horses of Java, var. *tarsata*, which has the second joint of the tarsi particularly developed and which he mentions as in some respects approaching *pilosus*.

The habits of this species are well known and have received mention for many years. They seem to accumulate more particularly upon colts or horses in pasture, but their presence becomes most manifest in the latter part of the winter, when they may become so numerous as to cause great irritation to the animals infested. They occupy more particularly the region of the neck, and also accumulate around the base of the tail and between the legs, and the animals will frequently rub bare places in these regions in their attempts to rid themselves from the irritation.

It is unnecessary to give any special notice regarding treatment, as they must be attacked on the same plan as other species.

Even if it proves that this species does not ordinarily infest the mule or donkey it would be policy not to allow these animals, if infested, to associate with horses, as we have no assurance as yet that they can not thrive on any of the members of the equine family.

BITING LICE OF CATTLE.

(*Trichodectes scalaris* Nitzsch.)

This species, which is a very abundant one upon cattle and occurs the world over, appears to have been first technically described by Linnæus (System. Naturæ, VII, p. 1017, No. 9,) under the name of *Pediculus bovis*, and evidently the same species is referred to under the name of *Pediculus tauri* (*Fauna Suecica*, 1946). Notwithstanding these descriptions, both of which were under a different genus from that in which it is now placed, the species was again described by Nitzsch (Germar's Magazine, III, 296) under the name of *Trichodectes scalaris*, and it has been known by this name in all of the numerous writings subsequent to this description. It has been treated by all writers upon the parasites of animals and is one of the best known species of parasitic insects. The effects upon the cattle infested are often quite serious on account of their great number, but they are apparently less injurious than the suctorial species which infest cattle. This injury depends, of course, upon

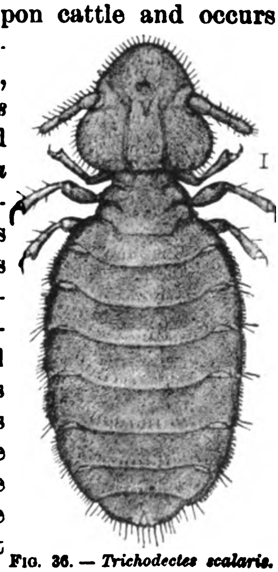

FIG. 36. — *Trichodectes scalaris*. (Original.)

* The hair line in the figure is about one-fifth longer than it should be.

the numbers occurring upon the individual, and somewhat upon the irritability of the animal infested. This species much resembles the form occuring upon horses, but is somewhat shorter, and the abdomen tapers less towards the extremity; the dark bands across the abdomen are also more distinct. They are generally found in greatest abundance in the spring of the year, at which time adults and eggs are discovered in great numbers. Their development corresponds with the other species, and they are subject to the same methods of attack.

They are very distinct from the suctorial species in appearance, and this difference is recognized by practical men, who speak of them as the "little red lice," as contrasted with the "blue lice," and they recognize too the difference in the trouble caused by the two species.

The application of kerosene emulsion or of tobacco decoction at seasons when this is practicable is effective, and we have found the process of fumigation described in the chapter on remedies to be effective, and this of course is applicable at all seasons of the year, even in cold weather, without danger to the animal.

FAMILY LIOTHEIDÆ.

LOUSE OF THE DOVE.

(*Menopon giganteum* Denny.)

This species of louse infesting doves is described by Denny (Anop. Brit., 225, f. 2, pl. 21). It does not appear to have been commonly observed since that time. A species is described under the name of *Menopon latum* (Piaget, Les Pedic., 457), which is probably the same as *Menopon giganteum*. As the species is evidently not a very abundant one, and the habits and remedies for this species are very similar to those for the *Menodon pallidum*, it is not necessary to enter into detail as to treatment. According to Denny, it is of a yellowish brown color, shining, the head with a small brown patch on each side, the prothorax with a cruciform depression and the lateral margin reflected.

THE COMMON HEN-LOUSE.

(*Menopon pallidum* Nitzsch.)

This species, probably the most abundant of all the lice infesting poultry, has been a familiar creature in the writings of entomologists and also in all the literature of poultry raising.

It was evidently recognized by Redi (Exper., tab. 16, Fig. 1), who figured it under the name of *Pulex capi*. Linnæus described it as *Pediculus gallinæ* (Syst. Nat., 1020, 32), and it is also mentioned by Panzer under the same name. Olfers described it under the name of *Nirmus trigonocephalus*, and Nitzsch, recognizing its true generic relations, gave it the name of *Menopon pallidum*. While Denny, Giebel, and Piaget

all agree in referring the figure by Redi to this species, Linnæus places it under his *Pediculus caponis*, which is equivalent to *Lipeurus variabilis* N.

The annoyance that this one species causes poultry is probably equal to that of all the other species combined, for it occurs in great abundance and almost every fowl examined will be found infested. Then, too, it passes readily to other species of birds, and many instances are recorded where horses kept near henroosts have been very seriously troubled by them. Some of these accounts seem hardly credible taken in connection with the habits of the insect, and we are inclined to think that the worst cases, at least, may have been due to the presence of itch mites on the poultry and the migration of them to the horses, though in such case we should expect the fowls themselves to show more serious injury. It is, at any rate, important to keep lousy chickens away from horses.

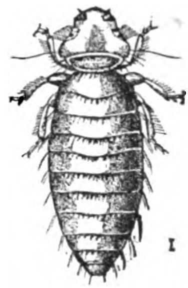

FIG. 37.—*Menopon pallidum*. (After Denny).

The louse is pretty easily distinguished from other common species infesting the hen by its light color and its great activity, running with great celerity among the feathers and from them upon the hands of persons holding fowls. It is from 1 to 1½ millietres in length, rather slender, and of a light straw-yellow color.

Remedies for this species must aim to reach the hiding places of the lice on the roosts and in the cracks of the walls of the henhouse as well as to destroy those on the fowl. Thorough fumigation and whitewashing, with careful attention to cleanliness, will do much to keep them in check. Pyrethrum, kerosene, etc., may be used direct upon the fowls, and if they are liberally supplied with ashes and road dust they will do much to protect themselves.

(*Menopon biseriatum* Piaget; *Menopon stramineum* Nitzsch.)

Under the above name Piaget describes a species of louse taken from the *Gallophasis cuvieri*, and which he speaks of as occurring also on the domestic fowl, the pheasant, and other birds. He says "Sur un *Gallophasis* (*Euplocamus*) *cuvieri* j'ai retrouvé le même parasite sur un *Gallus domesticus*, sur un *Phasianus colchicus*, sur un *Pavo spiciferus* male et femelle en assez grand nombre et dernièrement aussi sur une *Meleagris gallopavo*. Il se rapproche évidemment du *stramineum* de N., promenant d'une *Meleagris gallopavo*, dommage que la diagnose de Giebel (Epiz., p. 291) soit trop vague pour l'identifier, mais plus encore du *Pediculus Meleagridis* de Panzer (51 f. 20). Peut-être est-ce le parasite de Schrank No. 1019, recueilli sur le même oiseau."

It seems very probable that the description of Panzer, Nitzsch, Giebel, and Piaget all apply to the same insect, and if such is the case it would

carry the recognition of the species back to 1793 when it was described by Panzer under the name of *Pediculus meleagridis*.

It would seem to be confined more particularly to the Phasianidæ, and of these to infest particularly the peafowls and turkey, its occurrence on the hen being only occasional. It would evidently pass readily from any of these birds to others in the same family.

THE PHEASANT MENOPON.

(*Menopon fulvo-maculatum* Denny; *Menopon productum* Piag.)

Denny, in his Monograph published in 1842, describes and figures, under the name of *Menopon fulvo-maculatum*, a species of louse occurring on the quail and pheasant. Piaget describes also a species occurring on pheasants (*Phasianus pictus* and *P. colchicus*), which he considers as probably the same as Denny's, though neither the description nor the figure enable him to determine certainly.

According to Denny, "It is fulvous yellow and pubescent; head semilunar, with a pitchy transverse spot on each side; abdomen clavate, with pale spots on the lateral margin."

Piaget says it is very similar to *M. pallidum*, though distinct, and calls the color "jaune ocre, fauve sur les cotés de l'abdomen."

Piaget also describes a variety (*major*) taken from the *Lophopharus resplendens*.

THE PEACOCK LOUSE.

(*Menopon phæstomum* Nitzsch.)

This species is apparently confined to the peafowls, as since its description in 1818 it has been taken only from these birds. Piaget states that it occurs on three different species, *Pavo spiciferus*, *P. cristatus*, and *P. javanicus*. It has not been recorded from this country, but is likely to be found by searching these birds.

LOUSE OF THE GUINEA HEN.

(*Menopon numidæ* G.)

Giebel seems to have been the first to have mentioned this species and we may infer that it is usually not abundant. Piaget speaks of it as similar to the *Menopon phæstomum* N.

We have not had opportunity to make careful search for it, but it doubtless occurs on guinea fowls in this country. It would probably be difficult for an ordinary observer to distinguish between this and the common species infesting hens, and even if noticed in abundance on guinea fowls it would very likely escape mention.

LOUSE OF DUCKS.

(*Trinoton luridum* Nitzsch.)

Redi seems to have been the first to give mention of this very common species, it being figured in the Exper., Pl. XII, as the louse of the Teal. It is also figured by Albin (Pl. 46) under the same common name as quoted by Denny. Nitzsch described it in 1818 under the name given above, and the species has been fortunate enough not to have received any other designation since, although it hasbeen mentioned in most of the works referring to the parasites of domestic fowls or the parasites of birds. It is a very common species and occurs on a great many different species of ducks, so that it is unnecessary to try and enumerate the hosts. So far as we have seen or can learn from record, however, it is not known to occur on birds outside of the duck family (*Anatidæ*).

Its nearest ally is the goose louse, to be mentioned next, and it is easily distinguished from that by the difference in size and the more distinct markings in this species. The markings are shown in the accompanying figure, their distribution on the head, thorax, and abdomen being clearly indicated; the abdomen is a trifle narrower and the sides a little more parallel than in some specimens observed. It is 4 to 5 millimetres in length.

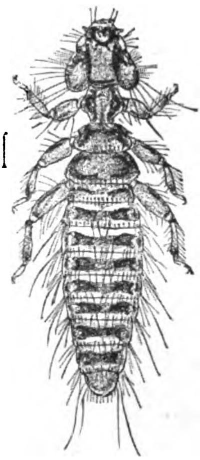

FIG. 38.—*Trinoton luridum.* (Original.)

LOUSE OF THE GOOSE AND SWAN.

(*Trinoton conspurcatum* Nitzsch.)

This species was evidently recognized at an early date, and is said to be mentioned by Sulzer under the name of *Pediculus anseris.* Nitzsch described it in 1818 under the name which has been universally adopted since, and it has received frequent mention since that time. It is very similar to the *Trinoton luridum*, but may generally be easily separated by the more diffuse coloring and its larger size, being 6 millimetres (3 lines according to Denny) in length. The two species are not known to infest the same kinds of birds. This species occurs on a number of species of geese and swans, and on one gull; according to Denny on the common domestic goose, on the *Larus canus*, and *Cygnus bewickii;* on *Cygnus olor*, according to Burmeister; on *C. musicus* and *olor*, according to Piaget; and on *Anser ruficollis*, according to Grube.

While the *Trinoton luridum* we have found to be rather common in America, the *conspurcatum* has not been met with, but the opportunities for examining geese have been limited.

LOUSE OF THE GOOSE.

(*Trinoton lituratum* Nitzsch.)

This quite distinct species of louse has been known to entomologists since 1818, when it was described by Nitzsch. Denny, however, did not recognize the application of the description to this form and redescribed it under the name of *Trinoton squalidum*. Later writers, however, have adopted the earlier name and there will probably be no further confusion regarding it.

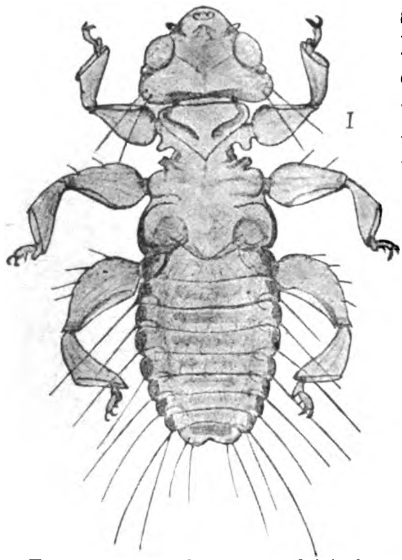

FIG. 39.—*Trinoton lituratum.* (Original.)

It is quite easily distinguished from the other species of Trinoton, being considerably shorter, smaller, and of a nearly white color.

It occurs, according to Denny, on *Anser albifrons*, the domestic goose, and on *Anas clypeata*. It is also referred to the Smew, and Piaget states that it is has been taken from *Dendrocygna arborea* and *Anser albifrons*.

THE PIGEON LOUSE.

(*Colpocephalum longicaudum* Nitzsch.)

Nitzsch described this form, which occurs on pigeons, in 1818, but it was again described by Denny in 1842, who gave it the name of *turbinatum*. Giebel retained both these names, evidently considering that they referred to distinct species, but Piaget has placed them together.

The species would not seem to be so abundant as some of the other species of Pigeon lice, and it has not been found as yet on pigeons that we have had an opportunity to examine.

It does not appear to have been found on any other birds, but has been taken from the common domestic pigeon and also the Turbot.

THE SWAN LOUSE.

(*Colpocephalum minutum* Rudow.)

Rudow seems to have been the first to recognize this species, though its occurrence upon the swan (*Cygnus musicus*) makes it rather strange that it should have escaped observation so long. It is a very small, species, as would be inferred from the name, and this may account in part for its not having been earlier noticed.

It has not been recorded from this country, but may be looked for upon our species of swans, as the lice infesting these birds are generally widely distributed.

LOUSE OF THE GUINEA PIG.

(*Gyropus gracilis* Nitzsch.)

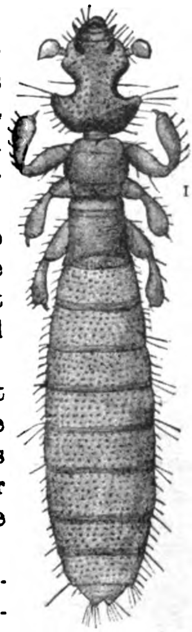

FIG. 40.—*Gyropus gracilis.* (After Denny.)

The Guinea pig is perhaps a rather unimportant factor among the domesticated animals, but it supports its due quota of parasites, nevertheless, and they require a brief mention at least. They are quite interesting in structure, differing largely from any of the species considered hitherto.

The one to first receive notice, and probably the one here given, was referred to by Schrank under the name of *Pediculus porcelli*, but Nitzsch, in 1818, described it as *Gyropus gracilis*, a name which has been used by all subsequent writers.

It is referred to generally by writers on the subject and would seem to be a fairly common species where guinea pigs are kept. It has not been met with in this country so far as records show, but may be looked for with great probability of success in any place where guinea pigs are kept in numbers.

Denny characterizes it as "elongate, pale, fulvous-yellow, finely pubescent; head and thorax darker, segments of the abdomen with transverse striated fascia at the sutures; tarsi and ungues very short and minute."

(*Gyropus ovalis* Nitzsch.)

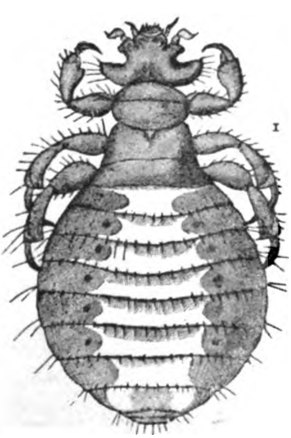

FIG.—41. *Gyropus ovalis.* (After Denny.)

This is a form closely related to the preceding species, and observed and described by Nitzsch at the same time. It differs from that species in the much shorter and broader body, and is, according to Denny, "pale yellow-white; head and thorax bright ferruginous, the former transverse; temporal lobes produced; abdomen large, nearly orbicular; legs thick, the two posterior pairs curved; ungues long, curved, and strong."

The scanty hair of the guinea pig makes the application of washes for the destruction of the lice a very simple matter, so that wherever it is a matter ot importance there need be no difficulty in ridding the animals of the parasites.

LOUSE OF THE POCKET GOPHER.

(*Trichodectes geomydis*, n. sp.)

Related to the Trichodectes infesting the larger mammals is a species which has been taken in immense numbers from the Pocket Gopher (*Geomys bursarius*), at Ames, Iowa. It was first taken in 1883 and since then has been collected from a great number of individuals, and I have also seen specimens taken from the western gopher, *Thomomys*, in a collection of parasites kindly loaned me by Mr. S. E. Cassino.

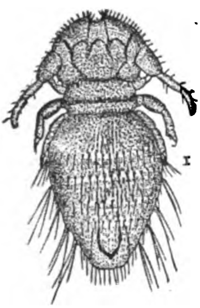

FIG. 42.—*Trichodectes geomydis*. (Original.)

Body robust and rather hairy. Antennæ very long, the basal segment enlarged, the head with a deep semicircular incision in front.

The head is rather wider than long and the antennæ are situated somewhat posterior to the middle and usually directed backward, very large and long, the joints nearly equal in length, but the basal are much enlarged in the male. Head with a deep semicircular incision on the otherwise semicircular anterior border, the posterior border slightly trilobed. Thorax short and broad; suture distinct; abdomen ovate, tapering regularly and rapidly to the anal segment. Genital apparatus of male distinct. The hairs are distributed evenly over border of head and sides of body; four central segments of abdomen with transverse rows of stronger hairs or weak spines, and the lateral posterior angles of all segments but the first with long bristles. Length, 1 millimetre.

The antennæ in male and the deep frontal incision separate this from any species known to me, and I think there is no question as to its being a distinct species.

INDEX.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN NO. 8.

(SECOND EDITION.)

THE

PERIODICAL CICADA.

AN ACCOUNT OF CICADA SEPTENDECIM AND ITS TREDECIM RACE, WITH A CHRONOLOGY OF ALL BROODS KNOWN.

BY

CHARLES V. RILEY, Ph. D.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

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DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., May 25, 1885.

SIR: I have the honor to submit for publication Bulletin No. 8 from this Division. On account of the concurrence the present year of two extensive broods of the Periodical Cicada, the one a 17-year, the other a 13-year brood, the inquiries in reference to this insect will be exceptionally numerous, and have, in fact, already begun to reach the Department. With the view of meeting the demand for information upon the subject, and with the further view of soliciting data that will enable me to more completely map out the geographical limits of these two broods, I have prepared this Bulletin. It is based upon an article published seventeen years ago, in my First Report on the Insects of Missouri, and is in fact to be looked upon as a revised edition of that article, with the omission of such passages as had but a local or temporary interest, and the addition of such chronological data as I have accumulated during the intervening time.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

THE PERIODICAL OR SEVENTEEN-YEAR CICADA AND ITS THIRTEEN-YEAR RACE.

The metamorphoses of insects, their instructive industry, their quarrels and their instincts afford abundant food for our love of the marvelous; but few species can claim such a singular history as can our Periodical Cicada. We are moved to admiration in contemplating the fact that an insect, after living for nearly seventeen years in the bowels of the earth, should at last ascend from its earthy retreat, change its sluggish, creeping, and wingless form, and, endowed with the power of flight, become a denizen of the air and enjoy the full glory of the sun. But our wonder increases when we reflect that this same insect has appeared in some part or other of the United States at regular intervals of seventeen years for centuries, aye, for ages, in the past! Long ere Columbus trod American soil this lowly insect must have appeared regularly at its appointed time. It must have filled the woods with its rattling song, when none but while beasts and savages were present to hear it. To me there is something pleasant in the idea that through its periodicity we are enabled with tolerable certainty to go back in thought, for centuries in the past, to a particular month of a particular year, or even to a given day, when the woods resounded with its song in the same manner as they did in 1868, or will the present year.

It was my good fortune to discover that besides the 17-year broods, the appearance of one of which was recorded as long ago as 1633, there are also 13-year broods;* and that, though both sometimes occur in the same States, yet in general terms the 17-year broods may be said to belong to the northern and the 13-year broods to the southern States, the dividing line being about latitude 38°, though in some places the 17-year broods extend below this line, while in Illinois the 13 year broods run up considerably beyond it.†

* See *Journal of Agriculture,* Saint Louis, June 13, 1868.

† Four months after I had published the above discovery I was gratified to find that Dr. Gideon B. Smith, of Baltimore, Md., in an unpublished manuscript communicated to me by Dr. J. G. Morris, of the same city, had made the same discovery, though he had never given it to the world; while five years later I learned through correspondence with Dr. D. L. Phares, of Woodville, Miss., that he had even anticipated Dr. Smith. There is nothing in Dr. Smith's manuscript to show that he was led to his conclusion by Dr. Phares, but the latter has, in *Southern Field and Factory* (published at Jackson, Miss.) for April, 1873, an extended article in which he claims to have published the fact of a periodical 13-year brood in the *Woodville* (Miss.) *Republican*

It so happened that one of the largest 17-year broods, together with one of the largest 13-year broods, appeared simultaneously in the summer of 1868. Such an event, so far as regards these two particular broods, had not taken place since the year 1647, nor will it take place again till the year 2089.

There are absolutely no perceptible specific differences between the 17-year and the 13-year broods, other than in the time of maturing; but while the insects forming these two classes of broods are not specifically distinct, they are good and distinct races which do not cross, and I have therefore, for convenience sake, named the 13-year broods *Cicada tredecim.*

TWO DISTINCT FORMS.

It is not a little singular, also, that two distinct forms occur in both races—a large one and a small one—the former by far more numerous than the latter. This fact has been observed in past years, and was

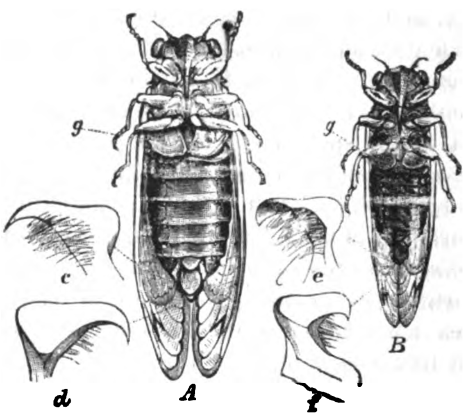

FIG. 1.—Seventeen-year Cicada. A, ♂ of typical form; c, d, genital hooks; g, singing apparatus. B, ♂ of the small form (*cassinii*): e, f, genital hooks. (After Riley and Hagen.)

noticed in 1868 by independent observers in different parts of the country.* Indeed, it was observed by Dr. Hildreth, of Marietta, Ohio, as far back as 1830 (*vide* Silliman's Journal, XVIII, p. 47). The true *Cicada septendecim* of Linnæus (Fig. 1 *A*, ventral view of male), as

as early as May 17, 1845, where he controverted Dr. Smith's position to the effect that there were no 13-year broods; and that in the same paper, for May 5, 1858, he published another notice, headed "*Cicada Tredecim.*" It was not till 1873 that I became aware of these facts, though I had previously been in correspondence with Dr. Phares; and though I have made every effort since to obtain a copy of the original article to which Dr. Phares refers, both he and myself have utterly failed to do so. While, therefore, it appears that Dr. Phares has trusted to memory for the dates here given, there is no reason to doubt the essential accuracy of the facts, and that to him rather than to Dr. Smith belongs the discovery of one of the 13-year broods of this Cicada, and the credit of having first published the fact.

* 1. Mr. V. T. Chambers, in the August (1868) number of the *American Naturalist*, p. 332, is said to point out some variation in color from those described by Dr. Fitch.

2. Mr. S. S. Rathvon favored me with specimens of both species from Lancaster

described by Harris and Fitch, occurs in the greatest numbers, both in the 17- and 13-year broods. It will measure, on an average, 1½ inches from the head to the tip of the closed wings, and almost always expands over 3 inches. The whole under side of the abdomen is of a dull orange-brown color, and, in the male more especially, four or five of the segments are edged with the same color on the back.

The other form (Fig. 1 *B*, ventral view of male) is not, on an average, much more than two-thirds as large, and usually lacks entirely the dull orange abdominal marks, though there is sometimes a faint trace of them on the edges of the segments beneath. This small form was described in 1851, by Dr. J. C. Fisher, in the "Proceedings of the Philadelphia Academy of Natural Sciences," vol. V, pp. 272–273, as a new species of Cicada, hitherto confounded with *septendecim*, and was named *Cicada cassinii*. His description was followed by a note from Mr. John Cassin, in which the latter states that the two forms show no disposition to associate together, and produce very different cries. The fact of the very great difference in the song of the males has been fully confirmed by the observations of M. C. Hill, of northeastern Ohio, who likewise found that the small form is very much less numerous than the large one.

The truest test of the specific distinction of these two forms lies in the comparative shape of the male genitalia, and the accompanying figures (*c*, *d*, *e*, and *f*, in Fig. 1), from drawings made in 1868 by Dr. H. A. Hagen, of Cambridge, Mass., show the male genital hooks of both. That of *septendecim* is represented on the outside at *c*, on the inside at *d*; and that of *cassinii* on the outside at *e*, and on the inside at *f*.

By these figures it will be seen that there are sufficient differences to separate the two forms as distinct; but while the hooks of the large kind (*septendecim*) are quite constant in their appearances, those of the smaller kind (*cassinii*) are variable, and in some few specimens are indistinguishable from those of the large kind. This circumstance, coupled with the fact that the small kind regularly occurs with both the 17- and 13-year broods, would indicate it to be a dimorphic form of the larger, and only entitled to varietal rank.

The large form has been observed to make its appearance from eight to ten days earlier than the small form (*cassinii*), and there is not a single specimen of the latter, among a number of the 13-year brood (*tredecim*) that I captured in May, 1868, though I took a few specimens afterward.

THE SEASON OF THEIR APPEARANCE AND DISAPPEARANCE.

The season of their appearance and disappearance differs somewhat with the latitude, though not so materially as one might suppose.

County, Pennsylvania, accompanied with the following: "I am justified, I think, in concluding these are two distinct species. They are different in size and coloration, produce entirely different stridulation, do not cohabit indiscriminately," &c.

3. The correspondent to the Department of Agriculture (July [1868] Rept.) from Hematite, Mo., says: "There are two species, one (both male and female) about twice the size of the other, and differing greatly, also, in their cries and actions."

According to the records they appeared in 1868 earlier in the South than in the North; but the last half of May can be set down as the period during which they emerge from the ground in any part of the country, while they generally leave by the 4th of July. In Saint Louis County, Missouri, in 1868, they commenced issuing on the 22d of May, and by the 28th of the same month the woods resounded with the rattling concourse of the perfect insect. As is the case with a great many other insects, the males make their appearance several days before the females, and also disappear sooner. Hence, in the latter part of the Cicada season, though the woods are still full of females, the song of but very few males will be heard.

That circumstances favorable or otherwise may accelerate or retard their development was accidentally proven, in 1868, by Dr. E. S. Hull, of Alton, Ill., as by constructing underground flues for the purpose of forcing vegetables, he also caused the Cicadas to issue as early as the 20th of March, and at consecutive periods afterwards till May, though, strange to say, these premature individuals did not sing. They frequently appear in small numbers, and more rarely in large numbers, the year before or the year after their proper period. This is more especially the case with the 13-year brood. Thus, in Madison County, in Illinois, and in Daviess and Clark Counties, in Missouri, there were in 1854 a few precursors of the true 1855 brood. They were also ob-

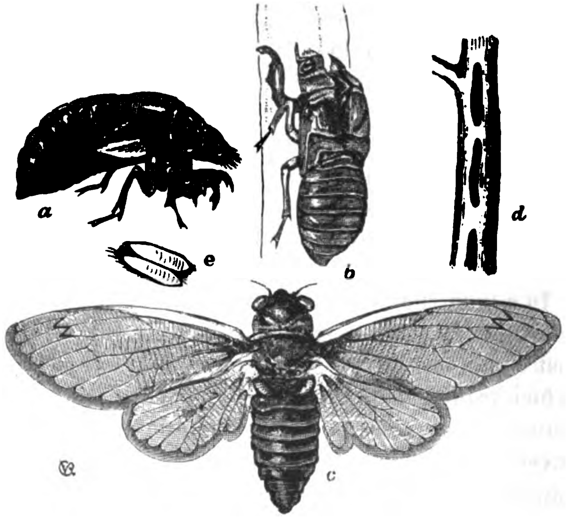

FIG. 2.—Seventeen-year Cicada: *a*, pupa; *b*, cast pupa shell; *c*, imago; *d*, punctured twig; *e*, two eggs. (After Riley.)

served in Madison County, Illinois, in 1867, while "L. W.", writing from Guntersville, Ala., to the *Country Gentleman*, of June 25, 1868, says, "some call them 14-year locusts." Other such cases will be noticed hereafter.

The natural history and transformations of the species have been described in the standard works of both Harris and Fitch, and in this connection I will merely mention a few facts not recorded by these authors.

Mr. S. S. Rathvon, of Lancaster, Pa., who has himself witnessed four of their periodical visits, at intervals of seventeen years, discovered the following very ingenious provision which the pupæ (Fig. 2, *a*) made, in 1868, in localities that were low or flat, and in which the drainage was imperfect. He says: "We had a series of heavy rains here about the time of their first appearance, and in such places and under such circumstances the pupæ would continue their galleries from 4 to 6 inches above ground (Fig. 3, *a* full view, *b* sectional view), leaving an orifice of egress even with the surface (Fig. 3, *e*). In the upper end of these chambers the pupæ would be found awaiting their approaching time of change (Fig. 3, *c*). They would then back down to below the level of the earth, as at *d*, and issuing forth from the orifice, would attach themselves to the first object at hand and undergo their transformations in the usual manner." Mr. Rathvon kindly furnished me with one of these elevated chambers, from which the accompanying drawings were made. It measured about 4 inches in length, with a diameter on the inside of five-eighths of an inch, and on the outside of about $1\frac{1}{4}$ inches. It was slightly bent at the top and sufficiently hard to carry through the mail without breaking. The inside was roughened with the imprints of the spines with which the fore legs of the builder are armed. In a field that was being plowed near Saint Louis, about the time of their ascent, I found that single, straight or bent, chambers were the most common, though there were sometimes several branching near the surface from a main chamber below, each of the branches containing a pupa. The same observations have been made by other parties. These holes are cylindrical and are evidently made by appressing the earth on all sides and throwing the refuse to the bottom, which must be quite a feat when they penetrate hard roads or come up between two rocks, as they frequently do.

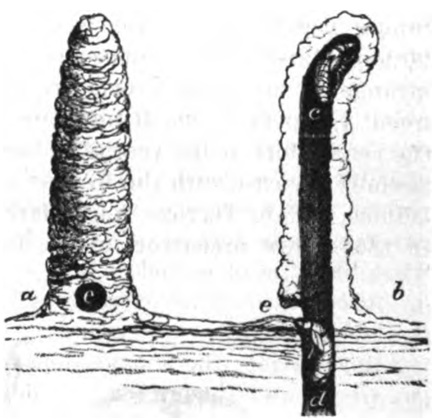

FIG. 3.—Seventeen-year Cicada: Galleries made by pupa; *a*, front view; *e*, orifice; *b*, section; *c*, pupa awaiting time of change; *d*, pupa ready to transform. (After Riley.)

The larvæ are frequently found at a great depth, notwithstanding the denial of the fact. Thus, Mr. Henry Sadorus, of Port Byron, Ill., who built a house in 1853, found that they came up through the bottom of his cellar in 1854, the cellar being over 5 feet deep, and Mr. F. Guy, of

Sulphur Springs, informed me that he had found them at a depth of 10 feet below the surface.

When ready to transform they invariably attach themselves to some object, and, after the fly has evolved, the pupa skin is left still adhering, as shown at Fig. 2, *b*. The operation of emerging from the pupa most generally takes place between the hours of 6 and 9 p. m.; and ten minutes after the pupa skin bursts on the back the Cicada will have entirely freed itself from it. Immediately after leaving the pupa skin the body is soft and white, with the exception of two black patches on the prothorax. The wings are developed in less than an hour, but the natural colors of the body are not acquired till several hours have elapsed. These recently-developed Cicadas are somewhat dull for a day or so after transforming, but soon become more active, both in flight and song, as their muscles harden. For those who are not informed of the fact, I will state that the males alone are capable of "singing," and that they are true ventriloquists, their rattling noise being produced by a system of muscles in the lower part of the body, which work on the drums under the wings, shown in Fig. 1, at *g g*, by alternately tightening and loosening them. The general noise, on approaching the infested woods, is a combination of that of a distant thrashing machine and a distant frog pond. That which they make when disturbed mimics a nest of young snakes or young birds under similar circumstances—a sort of scream. They can also produce a chirp somewhat like that of a cricket, and a very loud, shrill screech, prolonged for fifteen or twenty seconds, and gradually increasing in force and then decreasing.

After pairing, the females deposit their eggs in the twigs of different trees; and though for this purpose they seem to prefer the oaks and the hickories, they oviposit in almost every kind of deciduous tree, and even in herbaceous plants and in evergreens. I have seen their eggs in the Chestnut, Locust, Willow, and Cottonwood, in peach twigs of not more than one-eighth of an inch in diameter, and also in the stems of the common Eupatorium; while R. H. Warder, of Cleves, Ohio, has found them in the following evergreens: *Thuja occidentalis*, *Juniperus virginiana*, and *Abies canadensis*, but was unable to find any traces of their work in either of our common pines—*Pinus austriaca*, *P. strobus*, or *P. sylvestris*.

Dr. Harris (*Inj. Ins.*, p. 212) has well described the mode of ovipositing, and it is only necessary to add that the female always saws with her head upwards, *i. e.*, towards the terminal part of the branch, except when she comes in contact with a side shoot, when, instead of shifting a little to one side, she reverses her position, and makes two punctures in an opposite direction to the rest, and thus fills up the straight row close to the base of the side shoot. The eggs (Fig. 2, *e*) are of a pearl white color, one-twelfth of an inch long, and taper to an obtuse point at each end. They are deposited in pairs, but separated by a strip of

wood, which is wider—and thus causes the eggs to be further apart—at the bottom of the grooves than at their commencement. The punctured twigs bear the appearance of Fig. 4, and frequently break off and die, though the great majority remain green and recover from their wounds. Indeed there is every reason to believe that the eggs seldom hatch in those twigs which break off and become dry, but that the life and moisture of the twig are essential to the life and development of the egg, for the eggs are noticeably larger just before hatching than when first deposited, showing that they are, to a certain extent, nourished by endosmosis of the juices of the living wood. Mr. Rathvon has also recorded the fact that the Cicada eggs are always shriveled in twigs that are amputated by the Oak-pruner (*Stenocorus villosus*, Fabr.). In the healing of the punctured parts a knot usually forms over each puncture, and I represent at Fig. 5 a portion of an apple twig, sent to me by Mr. John P. McCartney, of Cameron, Clinton County, Mo., and which was punctured in the year 1862. Though the wounds had so well healed on the outside, the grooves in side were not filled up, but still contained the minute, glistening egg-shells, from which the young larvæ had escaped six years before.

FIG. 4.—Twig punctured by the Seventeen-year Cicada.

FIG. 5.—Twig healed after the puncture of the Seventeen-year Cicada.

The eggs hatch between the 20th of July and the 1st of August, or in about six weeks after being deposited. The newly-hatched larva (Fig. 6) differs considerably from the full-grown larva, but principally in having much longer and distinctly 8-jointed antennæ.* It is quite active, and moves its antennæ as dexterously and as rapidly as does an ant. As soon as it has extricated itself from an exceedingly fine membrane (the amnion), which still envelops it after it has left the egg,† our little Cicada drops deliberately to the ground; its specific gravity being so insignificant that it falls through the air as gently and as softly as does a feather.

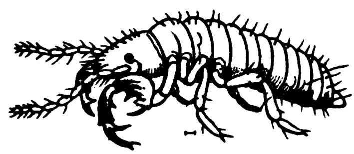

FIG. 6.—Seventeen-year Cicada. Newly hatched larva. (After Riley.)

* There is frequently a ninth joint partly developed.

† Most insects having incomplete metamorphoses are enveloped in a like membrane after leaving the egg, and until this is thrown off the young insect is awkward in its motions. In the case of the young Cicada, these fine membranes are usually left attached to the roughened orifice of their nidus, and thus form, together, a white, glistening bunch.

The cross-veins near the tips of the upper wings of the Periodical Cicada form a dusky zigzag mark in the shape of a W. Some persons are silly enough to believe that this mark portends war. It occurs alike, though not to such a marked degree, on all other Cicadas, and if people must have an omen let them rather take the two W's for *warm weather*, and it will not be likely to disappoint them.

ENEMIES OF THE CICADA.

Upon leaving the ground to transform, the pupæ are attacked by different quadrupeds, by birds, and by cannibal insects, such as Ground-beetles, Dragon-flies, Soldier-bugs, &c., while hogs and poultry of all kinds greedily feast upon them. In the perfect fly state they are attacked by at least one insect parasite, for dipterous maggots (the larvæ, probably, of some Tachina fly) may occasionally be found in their bodies. In this state they are also often attacked by a peculiar fungus, which was noticed by Dr. Jos. Leidy, in the Proceedings of the Philadelphia Academy of Natural Sciences for 1851, p. 235, and has since been described as *Massospora cicadina* by C. H. Peck (31st Rept. N. Y. State Mus. Nat. Hist., p. 44, 1879). Dr. W. D. Hartman, of West Chester, Pa., speaking of the occurrence of this fungus, in 1851, says: "The posterior part of the abdomen, in a large number of male locusts, was filled by a greenish fungus. * * * The abdomen of the infected males was unusually inflated, dry, and brittle, *and totally dead while the insect was yet flying about.* Upon breaking-off the hind part of the abdomen, the dust-like spores would fly as from a small puff-ball." One male specimen, received in 1868 from Pennsylvania, was affected by the same or a similar fungus, the internal parts of the abdomen being converted into what appeared to be a brown mold.

R. H. Warder, of Cleves, Ohio, in speaking of this mold, says: "It seemed to be a drying up of the contents and membranes of the abdomen, generally of a brown color, and dry and brittle. I found that in many cases the male organs of generation remained so firmly attached to the female during copulation that the male could only disengage himself by breaking away, leaving one or two posterior joints attached to the female, and it is these mutilated males which I found affected by the peculiar fungus mentioned, and therefore concluded that the 'dry rot' might be the result of the broken membranes. I never found one thus affected in the very early part of their season, and I never found a perfect male thus affected. But this is not positive proof."

THE SUPPOSED STING OF THE PERIODICAL CICADA.

It is astonishing what a wide-spread fear exists of the Cicada on account of its supposed stinging power. There is scarcely a paper in the United States but published some account of a "locust" sting in 1868, while unpublished accounts were equally numerous. One of the editors

of the Saint Louis *Republican* was kind enough to clip out for me all accounts of such stings which he found in its numerous exchanges, and the number which had accumulated before the end of the "locust" season was truly surprising. Some people even denied themselves the pleasure of eating blackberries, raspberries, and other fruits, because they feared these fruits had been poisoned by the eggs of Cicadas, while others believed that the insects poisoned water. I have endeavored to trace a number of these reports, but have invariably found that they were either false or greatly exaggerated, and there is no doubt whatever that the great majority of such accounts owe their origin to the fertile imaginations of newspaper reporters, who are ever ready for the sensational. Yet, as the saying goes, it is strange there should be so much smoke and no fire, and I will briefly review the only three methods by which such stinging can possibly be produced. At the same time I give it as my conviction that there is but little cause for fear, as I have handled thousands of them, and know hundreds of persons, including children, who have done the same, and yet have never been able to witness a single case of bona fide stinging by the Cicada.

BY HORNETS.—There is a very large digger-wasp (*Stizus grandis*, Say), the habit of which is to provision its nests with Cicadas. The burrows made by this digger-wasp, or hornet, are about 3 feet long, with two or three galleries about 1 foot long, each terminating in a chamber considerably enlarged. The female catches a Cicada, which she stings and paralyzes, and drags into one of these chambers; and it is not very unlikely that she should occasionally alight on some human being with a Cicada in her grasp, and upon being brushed off, should retaliate by stinging the offender, and then fly off, leaving the Cicada behind, which, in absence of the hornet, would very naturally be accused of the sting. An allied species of digger-wasp (the *Stizus speciosus* of Say)* has been actually observed by Mr. Rathvon to carry off a few belated individuals of the Periodical Cicada; but the usual prey of both of these species is the larger annual Cicada (*C. pruinosa* Say), and they both occur too late in the season to be the cause of all the stinging we hear of.

BY THE OVIPOSITOR.—The ovipositor of the female (Fig. 8, *b*) is certainly capable of inflicting a wound, but the Cicada is anything but pugnacious, and when not in the act of ovipositing, this instrument is securely inclosed in its sheath. That this is the stinging instrument is rendered extremely doubtful, for the following reasons: (1) All the stinging we hear of has been done suddenly, while the insertion of the ovipositor would necessarily be a gradual operation, requiring at least one minute; (2) the real function of the ovipositor is to convey an egg

* These wasps are now referred to the genus *Sphecius* Dahlb. and both *grandis* Say and *speciosus* Say ranked as one species, the former sinking to a varietal name of the latter, which has priority. (See W. H. Patton on "The Am. Bembecidæ: Tribe Stizini," Hayden's U. S. Geol. and Geogr. Survey, Bull. V, 1879, pp. 341–347.)

into the wound which it makes, and I have been unable to trace a single case where eggs were found in the flesh. All such accounts have proved to be fabrications, and the straightforward report which Mr. V. T. Chambers, of Covington, Ky., gave in the August (1868) number of the *American Naturalist*, of a negro being stung on the foot by a Cicada, proved, after all, to be a mistake, for "Mr. Winston did not see the insect with its instrument *in situ;*" (3) the three following facts, which are reliable, prove that stinging, in the usual sense of the term, by this instrument, is almost impossible: *First*, Mr. William Muir, associate editor of *Colman's Rural World*, carefully lifted a female from off a tree while she was yet in the act of ovipositing, and as carefully placed her on his little finger, holding it as near as possible in the same direction and position as the branch grew from which she was taken. She instinctively endeavored to continue ovipositing, and, holding firmly to his finger, tried again and again to insert the ovipositor, but without the least success, for it could not make the least impression on the soft and yielding flesh, but continually slipped from one side to the other. *Second*, it is recorded that Mr. Peter A. Brown, of Philadelphia, Pa., himself inflicted a puncture with the ovipositor, several times, upon his hand, without experiencing any more pain than that produced by the prick of a pin or any other pointed instrument, and that no swelling ensued. *Third*, Dr. Hartman, of Pennsylvania, introduced some of the moisture from the ovipositor into an open wound and it caused no inflammation whatever.

FIG. 8. — Seventeen-year Cicada, side view of ♀ to show beak, *a*, and ovipositor, *b*. (After Riley.)

BY THE BEAK, OR HAUSTELLUM.—The beak (Fig. 8, *a*) is an organ which both sexes of the Cicada possess, and by which they take their nourishment. I have seen them insert it into and extricate it from the branches of different trees, and know that the operation is quite rapid, and that the instrument must be quite sharp and strong. All the more authentic cases of stinging indicate this to be the instrument,* and it is quite likely that, just as the sting of a bee will affect some persons nigh unto death, and have no effect whatever on others, so the puncture

* Mr. D. B. Wier, of Lacon, Ill., who well knows the difference between the male and female Cicada, recollects distinctly that when they were there in 1854 he was stung in the finger by the male, the sting not causing very severe pain.

Mr. R. T. Parker, of Saint James, Phelps County, Missouri, an intelligent fruit grower, who has given some time to the study of insects, informed me that he was stung on the neck by a male Cicada, evidently with the beak, and that the sting was not so painful as that of a bee.

Dr. M. M. Kenzie, of Centerville, Reynolds County, Missouri, has communicated the fact that Frank Smith, aged fourteen years, living on Henpeck, in the lower part of Reynolds County, was stung by a Cicada on the back of the left hand. The wound healed by first intention, and the next morning there was only a black clot *about the size of a pin's head,* to mark its place, with scarcely any swelling.

of the beak of a Cicada will be more serious to some persons than to others. That there is no poison gland attached to this beak is no argument against its stinging power, for several true bugs are known to produce severe stings by their beaks, while the hairs and spines of some caterpillars have a similar power.

THE INJURY WHICH CICADAS CAUSE TO FRUIT TREES.—REMEDIES.

While living under ground they have been accused of killing pear trees, and more especially by Miss Margaretta H. Morris, in accounts of them published in 1846. The late Dr. Smith, of Baltimore, however, who made extensive observations, denied their being capable of such injury. He says:

"The larva obtains its food from the small vegetable radicels that everywhere pervade the fertile earth. It takes its food from the surface of these roots, consisting of the moist exudation (like animal perspiration), for which purpose its rostrum or snout is provided with three exceedingly delicate capillaries or hairs, which project from the tip of the snout and sweep over the surface, gathering up the minute drops of moisture. This is its only food. The mode of taking it can be seen by a good glass."—*In Prairie Farmer, December*, 1851.

The fact that they will rise from land which has been cleared of timber, cultivated, and even built upon for over a dozen years, would seem to contravene Miss Morris's statement, while their long subterranean existence precludes the necessity of rapid suction. It is also quite certain that they rarely kill trees, or we should oftener hear of it, and I have captured a gigantic but unnamed species of Cicada on the plains of Colorado, 50 miles from any tree, other than a few scattering willows.

The truth of the matter seems to be, that while they do puncture and derive nourishment from the roots of trees, they rarely if ever produce in this way any serious injury. This may be due to the fact of their slow development, and the necessarily small amount of nourishment taken at any one time. While I have not been able to prove, as asserted by Dr. Smith, that the bristles at the tip of the proboscideal sheath or labium are ever used as vehicles for nourishment, it is true that the larva is far more often found in a cavity away from any root whatever. than it is fastened to roots. Yet, often in digging for and studying this insect in its larva state, since my 1868 article was written, I have found the larvæ with beaks inserted; in fact they will frequently hang by the beak after they are dug up, and the rootlets of our forest trees, where Cicadas abound, show scars and often slight swellings such as one might expect from the punctures.

In the perfect state, however, the female is capable of doing great injury to trees by hacking up their twigs, in the process of ovipositing, and although their injury in the forest is not generally felt, it is a very different thing in our orchards, and especially in the nursery.

The following editorial from the old *Valley Farmer* of November, 1855, will show how serious the injury may sometimes be:

"We planted an orchard of the best varieties of apple trees last spring. We had taken particular pains, not only in selecting the best varieties, but in planting the trees, and hoped in a few years to partake of the fruit. But our hopes were destined to be blasted. The locusts during the summer destroyed nearly all of them; not one in six is living. To look at them one would think that some person had been drawing the teeth of a saw over the bark of every tree."

It also appears that in some instances they injure trees by the insertion of their beaks for nourishment, for Mr. Gustavus Pauls, of Eureka, had a young apricot tree which was so thoroughly punctured in this manner that he took a gallon of coagulated sap from it, and he attributes the death of some of his trees to this cause. I am convinced, however, that injury of this kind is comparatively rare.

On June 13, 1868, I was sent for by four different parties in Saint Louis County, who wished me to try and save their trees from the ruinous work of these Cicadas, which had by this time begun to deposit their eggs in earnest. I found that when the wind was high they could, by its aid, be driven to some extent, but that without its aid they could not be driven at all, as, when started, they are just as likely to fly behind as before you. I tried lye, whitewash, and sulphur, air-slacked lime, and finally carbolic acid, and found that none of these mixtures would affect them. Indeed, after experiments involving about $200, I am convinced that there is no available way of entirely preventing this ruinous work when they once commence to oviposit. The nursery of Mr. Stephen Partridge, a few miles west of Saint Louis, which is surrounded on all sides by timber, was more seriously injured than any other which I saw, and he lost many hundred dollars' worth of apple, peach, and pear stock. They also punctured his grape-vines very freely, preferring the Clinton and Taylor among varieties. By having all hands turn out early in the morning, and between 6 and 7 o'clock in the evening, while the insects hung listlessly to the branches, he succeeded in crushing thousands of them, and thus saved parts of his nursery from total ruin. But it becomes a hopeless task to try to stay their disastrous work when once they have acquired full power of flight; though, while in their feeble and helpless condition, as they leave the ground, they can not only be destroyed to far greater advantage by human agency, but hogs and poultry of all kinds eagerly devour them. There were, it is true, many accounts afloat in 1868 of hogs being poisoned by them, and, though it is not impossible that one was occasionally killed by over-glutting,* such cases were very rare indeed.

* Mr. T. R. Allen, of Allenton, informs me that during years when the Army Worm (*Leucania unipuncta*, Haw.) occurred in such swarms, hogs and chickens feasted on them to such an extent that the former frequently died, while the latter laid eggs in which the parts naturally white would be entirely green when cooked.

From the foregoing, the importance of knowing beforehand when to expect them becomes apparent, and the following chronological statement will not only prove of scientific interest but of practical value.

CHRONOLOGICAL HISTORY OF THE PERIODICAL CICADA, WITH DATES OF THE FUTURE APPEARANCE OF ALL WELL-ASCERTAINED BROODS THROUGHOUT THE COUNTRY.

As the facts in reference to the existence of a 13-year brood, recorded by Dr. D. L. Phares, in the Woodville (Miss.) *Republican*, and already referred to, were unknown to naturalists generally, and had remained unnoticed and unrecorded in natural history publications, it is only since the year 1868 that a number of these 13-year broods have been fully established. In that year I published the account of twenty-two distinct broods, including all the information that I could obtain at the time both as to 17-year and 13-year broods. The mass of material from which the generalizations were made would have been tedious and voluminous, if given in detail, and was necessarily omitted. The following chronology includes such additional data as I have been able to obtain in the intervening seventeen years.

But little increase in our knowledge as to the distribution of the different broods has been made, so that the chronology remains essentially the same. I have collected during that time, from correspondents and otherwise, numerous additional facts, but most of them, and among them the most trustworthy, relate to broods that were already well known; while of the smaller broods, and especially of those which are in need of confirmation, the additional data are extremely scanty. It should not be inferred, however, that those broods which have not been confirmed, are necessarily invalid; because the additional data have been obtained chiefly when I have made some effort in that direction, while some years, owing to absence from the country or other causes, I have neglected to make inquiry.

I shall therefore be very glad to receive from correspondents as full information, and from as many localities as possible, not only anent the two broods occurring this year, but any of the other broods mentioned in this chronology.

The passages in small type are in each case quoted from the work of 1868, with the exception of the headings, in which the two dates given are made to include the last and the next future appearance of the different broods.

While the discovery of the 13-year broods dispelled much of the fog in which this chronology had hitherto been wrapped, it at the same time rendered a complete and lucid exposition of that chronology extremely difficult. The northern boundary line of the 13-year broods is

about latitude 38°, but in Illinois one of them ascends between two and three degrees above this line, while the 17-year broods descend below it in several places, the two races sometimes occurring in the Carolinas. Thus the two races sometimes occupy the same territory; while two broods of the same race, appearing in different years, may also overlap one another, as in the instance given in the account of Brood XXII, in Virginia, where the "locusts" appear every eighth and ninth year. In order to make the subject as clear as possible, and to facilitate references, I have retained the numbering of the different broods given in 1868 in accordance with the sequence of their appearance from and after that date.

BROOD I.—*Septendecim*—1869, 1886.

In the year 1869, and at intervals of seventeen years thereafter, they will, in all probability, appear in the valley of the Connecticut River. According to Dr. Asa Fitch (N. Y. Rep., I, p. 40), they appeared there in 1818 and 1835, and according to Dr. Smith, they occurred in Franklin, Bristol, and Hampshire Counties, Massachusetts, in 1767, 1784, 1801, 1818, 1835, and 1852.

1869.—The genuineness of this brood was fully established in 1869, as its appearance in Connecticut that year was recorded by several different journals (*Amer. Entomologist*, I, p. 244), and in Massachusetts by a recent communication to the publishers of the *Scientific American* from Mr. Guilford H. Hathaway, of Fall River. He observed the Cicadas at Freetown, near Fall River, in the years 1818, 1835, 1852, and 1869, and adds: "In 1818 they were very numerous; in 1852 still less; and in 1869 they were quite scattering in comparison with 1818."

BROOD II.—*Tredecim*—1882, 1895.

In the year 1869 they will, in all probability, appear in Georgia, in Habersham, Rabun ?, Muscogee, Jasper, Greene, Washington, and adjacent counties, having appeared there in 1843 and 1856, according to Dr. Smith.

1869.—True to time, this brood appeared in great numbers, in 1869, in the northwestern part of Georgia, as I was informed by Mr. A. R. McCutchen, of Lafayette, Walker County, in that State. There is a great deal of evidence, however, which goes to show that it is the 17-year Brood XXII which occurs in the northeastern counties, and Mr. George P. Kollock, of Clarksville, Habersham County, wrote that the "locusts" were not there in 1869, but that they swarmed in 1868 and 1851. This 17-year brood seems to confirm Dr. Fitch's statement (N. Y. Report, I, p. 40) regarding the extent of his fourth brood, and it is further confirmed by the testimony of Mr. D. C. Sutton, of Lafayette, Ga., who wrote me on June 30, 1874, that "the 17-year brood of Habersham and the northeastern counties occurred in 1868, simultaneously with the 13-year brood [XVIII] of Walker County, and the northwestern part of the State.

The extent of this Brood II must therefore be limited. Habersham County must be stricken out, and no doubt Rabun also, while Walker and the adjacent northwestern counties should be added.

1882.—For the year 1882 I failed to get any further information about this brood.

BROOD III.—*Septendecim*—1870, 1887.

In the year 1870, and at intervals of seventeen years thereafter, they will, in all probability, appear in what is known as the "Kreutz Creek Valley," in York County, Pennsylvania, and possibly in Vinton County, Ohio, and Jo Daviess County, Illinois. Mr. S. S. Rathvon, of Lancaster, Pa., speaking of this brood, says: "Lancaster County is bounded on the southwest by the Susquehanna River, dividing it from the county of York, along the northeastern margin of which there is a mountain range, sloping down to the river. Along that slope Cicadas were abundant the present season (1868—Brood XXII). But on the southwest side of the range, in what is known as the Kreutz Creek Valley, there were none. They appeared last in this valley in 1853, and previous to that year at intervals of seventeen years from time immemorial." Dr. Smith records their appearance in 1853, both in Vinton County, Ohio, and Jo Daviess County, Illinois.

1870.—From all that I can learn, this brood is invalid, and has no existence. Mr. Rathvon failed to record its appearance in 1870 in the Kreutz Creek Valley, and the Rev. Dr. J. G. Morris, of Baltimore, Md., writes positively that it did not appear. He says: "Our Lancaster friend, Rathvon, was a little mistaken in presuming that this would be the year of the appearance of the Cicada in Kreutz Creek Valley, York County, Pennsylvania. I have made diligent inquiry of persons familiar with that district, and they report no locusts. Now, it may be that he gives that title to a district different from that which I know by that name (for I was born in that vicinity), but the Kreutz Creek Valley, 7 or 8 miles east of York, and bordering on the Susquehanna, was not visited this year by this singular Cicada."

I likewise failed to hear of the "locusts" either in Vinton County, Ohio, or in Jo Daviess County, Illinois, and as all three of the localities are restricted and widely separated, and as those in Illinois and Pennsylvania are within the range of Brood V, which occurs one year later, the insects recorded to have appeared in the localities named in 1853 were most likely precursors only of the more extensive Brood V.

BROOD IV.—*Tredecim*—1883, 1896.

In the year 1870, being the same as the preceding, they will, in all probability, appear in Jackson, Gadsden, and Washington Counties, Florida, having appeared there, according to Dr. Smith, in 1844 and 1857.

1870.—The appearance was confirmed in 1870, and, as the following communication will show, the brood extends even into Alabama, Mississippi, and Tennessee:

DEAR SIR: The 13-year brood of the Periodical Cicada, mentioned in your first Missouri report (your Brood IV), appeared, according to prediction, in northwestern

Florida this year, extending northward over Alabama and a good portion of eastern Mississippi, and into Tennessee as high as this point. I think I wrote you when they were here. They were not in great numbers at any point. I was at Mobile at the time of their appearance there, and found them singing quite merrily in the woods below the city.

J. PARISH STELLE.

SAVANNAH, TENN., *September* 2, 1870.

1883.—I received no reports for this year, but, if Mr. Stelle's word is to be depended on, there cannot be much doubt that this brood is well established, though it may not appear in great numbers at any place.

BROOD V.—*Septendecim*—1871, 1888.

In the year 1871, and at intervals of seventeen years thereafter, they will, in all probability, appear around the head of Lake Michigan, extending as far east as the middle of the State of Michigan and west an unknown distance into Iowa. Also in Walworth County and other portions of southern Wisconsin, and southward into Illinois. This brood is equal to Dr. Fitch's sixth. It extends all over northern Illinois and as far south as Edgar County, and its appearance in 1837 and 1854 is well and thoroughly recorded. In Champaign County, Illinois, it overlaps Brood XVIII, or the southern Illinois *tredecim* brood, while it also interlocks with Brood XIII (*septendecim*) in the same county.

They will also appear in the same years in the southeast by eastern part of Lancaster County, Pennsylvania, in what is called the "Pequea Valley," having appeared there in vast numbers in 1854.

The earliest known record we have of the appearance of Periodical Cicadas is in Morton's "Memorial," in which it is stated that they appeared at Plymouth, Plymouth County, Massachusetts, in the year 1633. Now, according to that date, one might be led to suppose that this recorded brood of Morton's belonged to this Brood V, as exactly fourteen periods of seventeen years will have elapsed between 1633 and 1871; but, strange to say, we have no other records of his brood than that in the "Memorial," whereas there are abundant records of their appearing one year later in the same locality, ever since 1787. There is, therefore, good reason to believe that the visit recorded by Morton was a premature one, and that it was properly due in 1634. I have therefore placed it in Brood VIII, and have little doubt but that if records could be found these would prove the Cicadas to have appeared in 1651, 1668, 1685, 1702, 1719, 1736, 1753, and 1770, as they did in 1787, 1804, 1821, 1838, and 1855.

1871.—Throughout the country mentioned in the first paragraph, the woods, orchards, corn-fields, and even meadows, were vocal with the shrill songs of these 17-year visitors. I was absent during the time of their appearance, but through the kindness of Dr. LeBaron, Mr. Suel Foster, of Muscatine, Iowa, Mr. H. H. McAfee, of the Wisconsin University, and several other correspondents, I am enabled to fix more precisely the northern, southern, and western boundaries of this brood. Thus, in Wisconsin we may draw a line from Milwaukee on the east, gradually southward to the middle of the southern line of Waukesha County, then making a sudden dip to the center of Walworth County, and rising again a little above the southern line of Jefferson County; then falling a little below Dane; then rising from the southwest corner of Dane to the northwest corner of Iowa County, and from thence along

the Wisconsin River to its mouth. There seems also to be a detached branch commencing about the middle of the northern part of Iowa County and running across the Wisconsin River into Sauk County. Incidentally with his studies on Brood XIII, Prof. C. E. Bessey, of Ames, Iowa, was able in 1878 to define the boundary of this Brood V of 1871, and to illustrate its extent in his State by a map published in the *Iowa Weather Bulletin* for November, 1878. The brood occupies nearly the whole eastern third of the State, not reaching, however, the southeastern corner and being limited toward the west by a line drawn from Mitchell County to a point on the Mississippi River somewhat south of the mouth of the Iowa River. In its southeastern portion this brood overlaps, therefore, Brood XIII. In Illinois the boundary line, in a general way, may be drawn from the northwest portion of Mercer County, southeast to the Illinois River at Peoria, west along the Toledo, Wabash and Western Railroad. There seem to be detachments extending farther south, especially in the eastern portion of the State, and they occurred as far south as Shelby County. In Indiana the line is not well defined, but includes the extreme northwest counties, extending as far south as the Kankakee River. In Michigan it does not extend north as far as Saint Joseph on Lake Michigan.

As this insect can only appear in districts which were timbered or planted to orchard seventeen years ago, it follows that in such an extensive prairie country as that within the limits indicated, the brood must be very much detached and scattered.

The insects did not appear in the Pequea Valley, in Lancaster County, Pennsylvania; at least I have been unable to get any authentic record of the fact.

From all I can learn, no Cicadas appeared at Plymouth, Mass., a fact which corroborates the view expressed in 1868, that the visit recorded by Morton in 1633 was a premature one, and that it was due in 1634.

The southern boundary of this brood in Illinois needs further definition. Mr. A. C. Hammond, of Warsaw, Hancock County, wrote me that in 1871 it did not occur at Warsaw, and the same statement was made to me by Mr. M. L. Dunlap in regard to the vicinity of Champaign.

Mr. S. S. Rathvon, of Lancaster, Pa., subsequently (May 17, 1872) informed me by letter that he had also failed in 1871 to hear anything of this brood in Pennsylvania.

Belated individuals of this brood were reported to me by Mr. E. S. L. Richardson, from Oswego, Kendall County, Illinois, on June 20, 1872, who also states at the same time that the Cicadas were there in 1837, 1854, and 1871.

BROOD VI.—*Tredecim*—1884, 1897.

In the year 1871, being the same year as the preceding, and at intervals of thirteen years thereafter, they will, in all probability, appear in the extreme southwestern

corner of Mississippi and in the adjoining part of Louisiana. Dr. D. L. Phares, of Newtonia (near Woodville), Miss., says that in 1858 they extended over most of Wilkinson and part of Amite Counties, Mississippi, and East and West Feliciana, Louisiana. He has himself witnessed the appearance of this brood during the years 1832, 1845, and 1858, while it is distinctly remembered by aged people in his neighborhood as having also appeared there in the years 1806 and 1819. Dr. Smith gives their range from the Mississippi River east to a ridge 45 miles from the river that divides the State north and south, and north and south to the boundaries of the State, recording them as occurring in 1806, 1819, 1832, 1845, and 1858.

1871.—This brood also appeared in 1871, and a few precursors were noticed in 1869, but none in 1870. I quote the following account of it from a letter from Dr. Phares: "A few males began to appear about the 20th of April. Not many of any kind came out till the 7th and 8th of May. On those two days, from 5½ till 8 p. m., or about dark, they came forth from the earth in vast numbers, and in large numbers from that time for ten days more, the last I noticed issuing on the 18th of May, and being mostly of the smaller and sometimes darker-colored individuals. Perhaps three-fourths of those coming up on the 7th and 8th of May were females. They are now (May 22) in full song, and I notice, with others, that when my large bell (412 pounds) is rung, they sing with redoubled fury."

Dr. Phares also sent me a large number of specimens and measurements to show that there is a variation of at least half an inch in the expanse of the wings, and that the small, dark form which has been named *cassinii* is connected with the larger normal form by infinite grades. He is more convinced than ever that the small form cannot be a distinct species, and that there should be no *C. cassinii* recognized; in which opinion I fully concur.

Regarding the possibility that a detachment of this brood exists in southern Illinois (Union County), I refer to my remarks on Brood VII.

In a communication to the *Southern Field and Factory*, August, 1873, Dr. Phares records the appearance of this brood since the year 1806, and defines its extent in Louisiana and Mississippi as follows:

"Their western limit is the Mississippi River, the southern about 8 miles north of Baton Rouge, the eastern about 4 miles west of Greensburgh, the county seat of Saint Helena, and 4 miles west also of Liberty, in Amite County, Mississippi, thus extending from 15 to 50 miles from the Mississippi River, and from the vicinity of the city of Baton Rouge, 108 miles to the northern limit of Claiborne County, Mississippi, perhaps even further. They, therefore, occupy East and West Feliciana, the northern part of East Baton Rouge, the northwest corner of Livingston, and the western part of Saint Helena parishes, Louisiana, and Wilkinson, Adams, Jefferson, Claiborne, and parts of Amite, Franklin, and possibly parts of one or two more counties in Mississippi."

According to Mr. J. W. Merchant (letter dated August 29, 1871), this brood did not appear at Carthage, Miss., which statement confirms the

extent of the brood as given by Dr. Smith and Dr. Phares, Carthage being east of the dividing ridge of the State of Mississippi.

BROOD VII.—*Tredecim*—1872, 1885.

In the year 1872, and at intervals of thirteen years thereafter, they will, in all probability, appear in Jackson County and around Cobden and Jonesborough, in Union County, southern Illinois, in Kansas, Missouri, Georgia, Louisiana, Tennessee, and Mississippi.

According to Mr. Paul Frick, of Jonesborough, they were in Union County, Illinois, in 1858, and he also thinks it was a great year for them *about* 1832. Those of 1858 were probably premature stragglers of the 1859 brood, while Mr. Frick is most likely mistaken as to the year 1832, since the Rev. George W. Ferrell, of Cobden, Union County, witnessed their appearance at that place in 1833, and also in 1846 and 1859; and Cyrus Thomas has also recorded their appearance in 1859 in the fifth report of the Illinois State Agricultural Society, page 458,* while a paragraph in the *Baltimore* (Md.) *Sun* of June 13, 1859, says, "The locusts have made their appearance in 'Egypt,' in southern Illinois, and cover woods and orchards in swarms." This brood not improbably extends westward into Missouri, for several of the old settlers around Eureka, in Saint Louis County, Missouri, recollect it being "locust year" about the time of its last appearance, while Mr. L. D. Votaw, of Eureka, and William Muir, of Fox Creek, Mo., both believe it was exactly nine years from 1868, or in the year 1859. Dr. Smith records it in DeKalb, Gwinnett, and Newton Counties, Georgia, in 1846 and 1859; in the northern part of Tennessee, also, in 1846 and 1859; in the whole eastern portion of Mississippi, from the ridge, which is 45 miles from the river, on the west, to the eastern boundary, in 1820, 1833, 1846, and 1859; in Carroll Parish, Louisiana, in 1859; and in Phillips County, Kansas, in the same year.

By referring to Brood XV, it will be seen that in 1846, or during the first year of the Mexican war, this 13-year brood appeared simultaneously with a 17-year brood in western Pennsylvania and Ohio.

1872.—For this year we have records of the reappearance of this brood from the following localities: In southern Illinois it appeared in Union County, as witnessed by a correspondent of the *Saint Louis Republican*, who writes, on May 31, 1871, from Cobden: "This section of country is quite lively and animated at present, a great portion of the life being supplied by the locust, whose shrill monotone meets and oppresses the ear in all directions. There is no escaping that tiresome tune, and we can only wish, vainly enough, that the noisy insects would introduce some variations into their ceaseless song. During the past week they have been coming out of the ground in myriads, and the trees are loaded with them, as they deposit their eggs in the bark of the young and tender branches." Another correspondent from "Egypt," of the same county, states that the locusts have appeared there true to prediction; that the woods are now ringing with their song, and that he knows of the appearance of the brood in 1846 and 1859. Among my own correspondents, Mr. Parker Earle (letter dated May 25, 1872) and Mr. S. H. Beckwith, of South Pass, stated that they abounded at Cobden, Union

* If Mr. Paul Frick is correct, the brood he has witnessed may possibly be a detachment of the Mississippi and Louisiana Brood VI; in which case the Cicadas appear for two consecutive years in Union County, Illinois, as they do (see Broods XIII and XIV) in central Ohio and portions of northwestern Missouri.

County, the latter adding that he caught about a dozen precursors in 1871. Mr. J. B. Miller, residing at Anna, in the same county, wrote (May 17, 1872), "they are here in hosts, according to prediction," and that he can trace the brood back to 1846. Finally, Mr. J. R. Muhleman (June 20, 1872) stated that a few stragglers of this brood extend as far north as Woodburn, in Macoupin County.

In Missouri the existence of this brood was fully established in 1872, though the exact limits of its range still remain to be defined. From Saint Louis County, Mr. H. J. Schulte, of Carondelet (letter June 10, 1872), reported them as being generally distributed throughout his section of the county, and on June 7 I noticed quite a number of Cicadas near Eureka and a few around Kirkwood. The only other place in that State from which this brood was reported is Rocheport, in the extreme southwestern corner of Boone County. Mr. M. P. Lientz, writing from that place on June 3, 1872, says that the Cicadas were thick enough there to make the woods noisy. Boone County is considerably west of Saint Louis County, but nearly in the same latitude.

Nothing was heard from Kansas to confirm or contradict Dr. Smith's statement regarding the occurrence of this brood in Phillips County.

From Tennessee the brood was reported in Madison County. The *Jackson Whig and Tribune* of May 25, stated that "they are doing their level best to make the woods north of the town vocal with their million voices;" and in the extreme southwestern corner, as Mr. W. Phillips, of the University of Mississippi, wrote me on January 22, 1873, they were below and about Memphis in their usual quantities.

In Mississippi they were, according to Mr. J. P. Stelle, swarming at Hazlehurst, Copiah County. According to Dr. George Little (as communicated to me by Mr. W. Phillips), they appeared at Oxford, Miss., in 1859 as well as 1872.

That this brood occurs in Arkansas seems to be proved by a communication of Mr. J. W. Howard, of Flat Bayou, to the *Phillips Southern Farmer*, October, 1872, stating that 1872 was the locust year in his section of the country.

Neither from Louisiana nor from Georgia did I receive any information in 1872 concerning this brood.

The existence of this brood has thus been verified in the parts of Illinois, Missouri, Tennessee, and Mississippi indicated above, and Arkansas has to be added thereto, while the other localities (Kansas, Georgia, and perhaps also Louisiana) require further verification this year (1885).

BROOD VIII.—*Septendecim*—1872, 1889.

In the year 1872, being the same year as the preceding, and at intervals of seventeen years thereafter, they will, in all probability, appear in the southeastern part of Massachusetts; across Long Island, along the Atlantic coast to Chesapeake Bay, and up the Susquehanna at least as far as to Carlisle in Pennsylvania; also in Kentucky, at Kanawha in West Virginia, and Gallipolis, Ohio, on the Ohio River. This is the

brood referred to in Brood V, and which there is every reason to believe is the one recorded by Morton in his "Memorial," as occurring in 1633.

Dr. Fitch, in the account of his third brood (New York Report, I, page 39), says: "The third brood appears to have the most extensive geographical range. From the southeastern part of Massachusetts it extends across Long Island and along the Atlantic coast to Chesapeake Bay, and up the Susquehanna at least as far as to Carlisle in Pennsylvania; and it probably reaches continuously west to the Ohio, for it occupies the valley of that river at Kanawha in [West] Virginia, and onwards to its mouth, and down the valley of the Mississippi probably to its mouth, and up its tributaries, west, into the Indian Territory. This brood has appeared the present year, 1855, and I have received specimens from Long Island, from South Illinois, and the Creek Indian country west of Arkansas," &c.

There is every reason to believe that Dr. Fitch, in this account, has confounded this *septendecim* Brood VIII, with the great *tredecim* Brood XVIII, for it so happened that they both occurred simultaneously in 1855, but the exact dividing line of these two broods is not so easily ascertained. Certainly, after reaching the Ohio River, the *septendecim* brood extends beyond Gallipolis, Ohio, for Professor Potter, in his "Notes on the Cicada decem septima," records their appearance at that place in 1821; and Dr. Smith records their appearance at Frankfort, Lexington, and Flemingsburg, Ky., in 1838 and 1855. But I strongly incline to believe that well nigh the rest of the territory mentioned by Dr. Fitch was occupied by the *tredecim* brood, the reasons for which belief will be found in the account of Brood XVIII.

Cicadas also appeared in Buncombe and McDowell Counties, North Carolina, in 1855, but until they appear there again it will be impossible to say, positively, whether they belong to this *septendecim* Brood VIII, or to the *tredecim* Brood XVIII.

1872.—The reports I was able to obtain for this year are as follows:

Mr. F. G. Sanborn wrote us on January, 1873, that he could find no trace of the appearance of this brood in Massachusetts in 1872. Dr. Packard, however (*Amer. Nat.*, VII, p. 536), says they appeared in the southerly part of the State. Moreover, the existence of this brood in southeastern Massachusetts has been fully confirmed by the following letter we received on January 17, 1873, from Mr. W. C. Fish, East Falmouth, Mass.:

"The seventeen-year locusts were very abundant here the past season, and did much damage in the woodlands, particularly among the young oak sprouts of a few years' growth, and in some of these localities where there were no large trees they completely riddled the huckleberry bushes. Between here and Sandwich there is a continuous tract of woodland. Sandwich is 15 miles north of us. This tract of woodland extends through a large portion of Plymouth County. I know that the locusts occurred through nearly all of this tract from Plymouth south and east through the towns of Sandwich and Falmouth, and east through the towns of Barnstable and Yarmouth. I do not know whether the brood extends further east down the Cape or not. It seems a little singular that when it occurs in such abundance here on the shore of Vineyard Sound, that they should come another year on the island of Martha's Vineyard so near us."

In New York the appearance of this brood in 1872, on Long Island, seems to be confirmed, as Mr. S. S. Rathvon wrote us (July 16, 1872) that

he saw a paragraph in the *U. S. Gazette* which reported the Cicadas to be in abundance on that island.

From Pennsylvania Mr. Rathvon sent us (July 16, 1872) a diagram illustrating the extent of the brood as observed by him in 1872, viz: Franklin, Adams, York, Lancaster, and Chester Counties, the Cicadas being mostly confined to woody portions along streams.

In Kentucky the brood was observed in the northwestern portion of the State, extending, according to the late Mr. V. T. Chambers, into the central portion beyond Lexington. According to newspaper items, the Cicadas were abundant in Richmond, Madison County, and Mr. T. W. Gordon, of Georgetown, Ohio, reported them from Maysville, Ky. The same gentleman stated also that his son caught several at Maysville in 1871, and these were no doubt forerunners of this brood.

All reports we received from Ohio came from the southwestern corner of the State. On May 25 Dr. John A. Warder brought me specimens from Cleves, Hamilton County. Mr. C. L. James, of Waynesville, Warren County, said, in a letter of June 10, that "they are there in full force, but not so many as in 1855; that fungus disease attacked the females by thousands. The brood in 1838 exceeded anything he ever saw." In Brown County the brood was observed by Mr. T. W. Gordon, of Georgetown, and Mr. S. Shepherd, of Hennepin, Ill., wrote me, on November 22, 1876, that he observed the brood in Brown County in 1804 and 1821. An item of the Prairie Farmer Record, dated May 26, 1872, and signed "D. M.," states "that the 17-year locusts are on hand in Clinton County." Finally Mr. Chambers (letter June 17, 1872) stated that the Cicadas extended some miles northeast from Cincinnati. Thus the brood is now fully confirmed in Ohio, though its eastward extension in that State still remains rather indefinite.

The isolated localities in North Carolina mentioned in the above quotation from my first Missouri report were not confirmed in 1872, which is an additional proof that the Cicadas which appeared there in 1855 belong to Brood XVIII. Nor did I get any news from the isolated locality in West Virginia mentioned above, though an eastward extension of the brood through eastern Kentucky to southern West Virginia is by no means impossible.

The most interesting result of the observations in 1872 is, however, the fact that this brood has a much greater westward extension than was previously supposed. In Indiana, Mr. O. S. Westcott, a well-known entomologist, found the Cicadas all along the Evansville and Crawfordsville Railroad, extending from Evansville certainly as far as Terre Haute, but not reaching east as far as Shoals, in Martin County. From Illinois another trustworthy observer, Mr. S. Shepherd, formerly residing in Brown County, Ohio, but having afterward moved to Hennepin, Putnam County, Illinois, wrote me on November 22, 1876, that he saw this brood at his present residence in 1838 and 1855. This occurrence of the brood in Illinois was also confirmed by a newspaper item from

the *Prairie Farmer*, briefly recording the appearance of Cicadas in McLean County.

Upon reviewing the localities of this brood as now ascertained we find that they represent a comparatively narrow curve with the ends pointing northward. The northeastern extremity commences in southeastern Massachusetts; thence the line goes south to Long Island; thence west through Pennsylvania, southern Ohio, and northern Kentucky to southern Indiana; thence again bending northward and reaching central Illinois with its northwestern extremity. This large belt is, however, by no means entirely occupied by the brood, and two large, compact central areas are plainly distinguished, one being in southeastern Pennsylvania, the other in northern Kentucky and southwestern Ohio. To the west there are two detached areas, one in southwestern Indiana, the other in central Illinois, while to the east there are again two detached areas, one on Long Island and the other in southeastern Massachusetts.

BROOD IX.—*Septendecim* (?)—1874, 1891.

In the year 1874, and at intervals of seventeen years thereafter, they will probably occur in southeastern Nebraska.

The occurrence of this brood was communicated to me by Mr. Clarke Irvine, of Oregon, Holt County, Mo. The brood is most likely confined to the eastern or timbered portion of the State, and I judge it to be *septendecim*, from the fact that the latitude is rather more northerly than *tredecim* is known to occur.

1874.—Whether this brood is a 17-year or 13-year one still remains somewhat doubtful, with the probability in favor of the former; but its existence and, at the same time, its extent westward to Colorado seem to be confirmed by a letter from Mr. J. H. Rice, of Gold Hill, Boulder County, Colorado, dated July 31, 1874, stating that the Cicadas occurred there in 1874, but not very abundantly. While it is true that this locality in Colorado is widely detached from that in southeastern Nebraska, yet we do not doubt that the Cicadas of both localities belong to the same brood. In these less timbered western States the broods must naturally be very much broken up, and appear in scattered localities and not in compact regions, as in the timbered States.

In this connection I would mention that on May 17, 1872, Mr. J. B. Miller informed me of a brood between the headwaters of the Smoke Hill River and Denver City, Colorado, in 1858. "Their work was plainly visible on a grove of young pitch pines." If these Cicadas were not stragglers of this Brood IX, but belong to some other brood, they would be difficult to place among the broods here enumerated. If they are a 13-year brood they could only belong to our Brood VI, which is extremely improbable. Moreover, it is not likely that central Colorado possesses a 13-year brood. If they belong to the 17-year race they would indicate a brood not yet enumerated and to be placed between my Broods IX and X. Although I have no reason to doubt the correctness of Mr. Miller's statement, yet it must be remembered

that errors in referring old observations to a particular year are easily made. For this reason I am unwilling to establish a new brood on the strength of this single testimony, and prefer to attach this locality to this Brood IX until the contrary has been proven. Neither in the year 1871 nor 1875 did I learn anything of the appearance of Cicadas in the locality mentioned by Mr. Miller.

BROOD X.—*Tredecim*—1875, 1888.

In the year 1875, and at intervals of thirteen years thereafter, they will most likely occur in different parts of Texas. According to Dr. Smith they appeared in vast numbers in some parts of Texas in 1849, though he was not able to get any particulars.

1875.—The year 1875 did not furnish any information regarding this brood, the existence of which is, therefore, solely based upon Dr. Smith's statement. That Dr. Smith himself was unable to obtain definite localities for this brood might justly be regarded as a suspicious circumstance, and should the year 1888, in which the reappearance of the Cicadas may be looked for, also fail to confirm this brood, it would be best to strike it entirely from the list of the well-established broods.*

BROOD XI.—*Septendecim*—1876, 1893.

In the year 1876, and at intervals of 17 years thereafter, they will, in all probability, appear in parts of North Carolina, Virginia, Maryland, Illinois, and Indiana. According to Dr. Smith they appeared from Raleigh, N. C., to near Petersburg, Va., in 1842 and 1859; in Rowan, Davie, Cabarras, and Iredell Counties, in the same State, in 1825, 1842, and 1859; in the valley of Virginia, as far as the Blue Ridge on the east, the Potomac River on the north, the Tennessee and North Carolina lines on the south, and for several counties west, in 1808, 1842, and 1859; in the south part of Saint Mary's County, Maryland, dividing the county about midway east and west, in 1825, 1842, and 1859; in Illinois, about Alton, in 1842 and 1859; and in Sullivan and Knox Counties, Indiana, in 1842 and 1859.

1876.—Although this brood is thus well recorded in former years from many sections of the country, I received but few data in reference to it in 1876—a fact due to preoccupation with other matters. A correspondent at Lexington, Va., recorded their appearance at his place in the

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* The only information which might possibly be referred to this brood is contained in a letter we received July 1, 1875, from Dr. D. L. Phares, and which reads as follows:

"About the 10th of June [1875], coming up the Mississippi River from New Orleans, at Bayou Sara, I heard of a family of Cicadas in West Feliciana Parish, Louisiana, near the river and south of Bayou Sara. I requested a gentleman to get what history he could of them and send me specimens. I have received nothing from him except the specimens I send herewith—all dwarfs, or perhaps a distinct variety."

It will be difficult to attach these specimens, either as precursors or belated specimens, to any one of the recorded broods, unless to this Brood X, of which they may possibly be the easternmost outpost. Still, as this isolated family of Cicadas has been observed east of the Mississippi, and therefore in a locality widely separated from Texas, nothing that is certain can be said regarding the connection of this swarm with Brood X.

New York Weekly Tribune June 24, 1876, and at the same time sent me a few specimens.

In the *American Entomologist*, vol. III, p. 77, the late Mr. V. T. Chambers stated that he found the Cicada in Cheyenne Cañon, Colo., in June, 1876, and this statement very probably indicates a detached outpost of this seventeen-year brood XI, since, as I have already said, it is not probable that northern and central Colorado possess a seventeen-year brood.

BROOD XII.—*Septendecim*—1877, 1894.

In the year 1877, and at intervals of 17 years thereafter, they will, in all probability, appear in the vicinity of Schuylerville and Fort Miller, in New York; thence along both sides of the Hudson to its mouth, where they extend, at least, to New Haven, in Connecticut, and west across the north part of New Jersey and into Pennsylvania; also in Dearborn County, Indiana; Kalamazoo, Mich.; in Pennsylvania, North Carolina, Virginia, and Maryland.

This brood is recorded by Professor Potter as having occurred at North Haven, Conn., in 1724, 1741, 1758, 1792, 1809, and 1826. It was also recorded by the same writer as having occurred in 1826 in Middlesex County, New Jersey, and by Dr. Fitch as having occurred in 1843 throughout the whole country mentioned above. In 1860, again, it was spoken of in the old series of the *Prairie Farmer* (vol. 22, p. 119) as having occurred that year in New Jersey, and Dr. Smith records it throughout the whole State in 1775, 1792, 1809, 1826, and 1843. Mr. James Angus, of West Farms, Westchester County, New York, has himself witnessed its recurrence in the years 1843 and 1860.

In Pennsylvania, Mr. Rathvon found a few individuals in 1860, and Dr. Smith says it extends from the Susquehanna to the Delaware River, bounded by Peter's Mountain on the south. In Virginia it occurred from the south part of Loudon County to the Roanoke River, and from the Blue Ridge to the Potomac, in 1826, 1843, and 1860; in Maryland from Anne Arundel County to the north part of Saint Mary's, and from the Potomac to Chesapeake Bay, in 1809, 1826, 1843, and 1860; in Rockingham, Stokes, Guilford, Rowan, Surry, and adjacent counties, North Carolina, in 1792, 1809, 1826, and 1843; in Dearborn County, Indiana, in 1843 and in 1860; and in Kalamazoo, Mich., during the same years.

1877.—This is one of the best recorded broods; and as it appears in the immediate vicinity of New York, Brooklyn, Jersey City, and other great centers of population, the records for the year 1877 are abundant in newspaper articles as well as in letters from correspondents. The reports from New York State agree that in 1877 the Cicadas were extremely abundant on Staten Island, much less so on Long Island, while there were none within the city of New York.

Along both sides of the Hudson River they were observed at many points, reaching so far north as in the vicinity of Troy in Rensselaer County, thus exactly confirming the extent of the brood as given above.

In Connecticut they were observed by Mr. William H. Patton, who wrote me as follows on July 3, 1877: "May 12th, large numbers of pupæ were found under stones in woods near Meriden, Conn.; May 27th, I saw the first perfect insect here in New Haven, and can find no knowledge of its earlier appearance, although I heard rumors of its appearance before that date. At the present writing they are still plentiful in the limited localities which they frequent."

In New Jersey they were seen and heard at many points in Hudson, Bergen, Essex, and Middlesex Counties, and much less frequently in other parts of the State; but Mr. A. E. Newton, of Ancora, in Camden County, observed them near his place, and wrote me on June 25, 1877: "From what I hear from other localities I judge that southern New Jersey generally, as well as northern, is subject to the visitation. They are doing little damage." Thus Dr. Smith's statement that they occur throughout the State seems to be confirmed.

In Pennsylvania, according to a communication to the *New York Weekly Sun* from Milford, dated June 11, they appeared in immense numbers in Pike County, having been much less numerous in 1860.* No news came to me from the southern portion of the State, where this brood is evidently not numerous.

I received no information concerning the localities above mentioned in Indiana and Michigan in 1877, but the records from Virginia are again numerous. Thus, Mr. William Hunter, Accokeek Mills, near Mount Vernon, Fairfax County, wrote, on June 4, 1877, that the Cicadas were thick near his mill and in his neighborhood, as they were also in 1860. "They are most plentiful on the hills, but some exist also in the valleys, and there are some localities where none are found, although surrounded on all sides by the infested neighborhoods." Mrs. Annie Noyes Higgs briefly announced the appearance of the Cicadas, beginning May 27, near Glendower, in Albemarle County; Mr. T. G. Legatt, of Lynchburg (letter of June 8, 1877), records the Cicadas from the vicinity of Lynchburg and from the counties immediately adjoining the city; and Mr. G. Underhill announced, in a card of June 4, 1877, their appearance at Fork Union, Fluvanna County. The brood is thus more widely distributed in Virginia than would appear from my record of 1868, and there is but little doubt that it extends to the southern limits of the State.

From Maryland I have a record only from Charles County, by Mr. William Hunter, who stated that the Cicadas were much less numerous there than in the hilly portions of Fairfax County, Virginia.

In the District of Columbia this brood was observed by many residents of Washington in 1877, so that the District must be added to the above localities.

BROOD XIII.—*Septendecim*—1878, 1895.

In the year 1878, and at intervals of seventeen years thereafter, they will, in all probability, appear along the center of the State of Illinois, all along the southern part of Iowa, and around Saint Joseph, in Buchanan County, in northern Missouri.

The records are abundant of their appearance in 1844 and 1861 all along the southern border of Iowa, and in Mason, Fulton, McDonough, and Champaign Counties, in central Illinois. In 1861 they also occurred in Champaign County, central Ohio, and in Buchanan County, northwestern Missouri; and this brood doubtless occupies, more or less, the whole strip of country between these two points. Their appearance in 1861 was associated with the first year of the rebellion, and Dr. Smith records this brood both in Illinois and Iowa in 1844.

* Professor Leidy (Proc. Ac. Nat. Sc. Phil., 1877, p. 260) briefly records their appearance near Easton, Northampton County.

1878.—The most compact body of this brood appears to be in Iowa, where its appearance in 1878 was carefully studied by Prof. C. E. Bessey, then of the Agricultural College at Ames. He illustrated the region occupied by the Cicadas in 1878 by a map attached to the *Iowa Weather Bulletin* for November, 1878, and treats more fully of the distribution of this and other broods in his State, in an article published in the *American Entomologist*, vol. III, p. 27, the article being also accompanied by a map. Professor Bessey gives there a list of counties in which the Cicadas were observed in 1878, and sums up the result as follows: "Twenty-eight counties were reported as having more or less of the Cicadas in 1878, and they are seen on the map to occupy a large area extending from the southeastern portion of the State northwestward up the Des Moines River. This area includes several counties from which no replies have been received, but in which doubtless the Cicadas appeared; these added to the reported counties make the whole number thirty-three or thirty-four, or say, one-third of the State. A careful calculation shows this area to include from 18,000 to 20,000 square miles. Its northern, or more properly, its northeasterly margin is parallel with the Des Moines River, and distant from it about 50 miles, running from near the city of Muscatine to Hamilton County, when it bends off southwestwardly to Cass County and thence to the State line in Decatur County. That part of the area lying southward, or southwestward of the Des Moines River is considerably broader than that on the northeast, being from 60 to 70 miles in width." In connection with these publications Professor Bessey states that the brood of 1878 was generally less numerous that year than at its preceding appearance in 1861; and, further, that it overlaps the brood of 1871 (Brood V) along the lower course of the Iowa River.

From these well-established data regarding this brood in Iowa one would suppose that it must occupy many of the northernmost counties of Missouri, but neither from that State nor from Illinois did I receive any reports in 1878. The detached locality in central Ohio has also remained without confirmation.

BROOD XIV.—*Septendecim*—1879, 1896.

In the year 1879, and at intervals of 17 years thereafter, they will, in all probability appear in the whole of western Missouri, commencing south about Johnson and Saline Counties, and extending in a northwesterly direction to Lawrence and above, in Kansas, south to Arkansas, and west an unknown distance into Kansas; also in central Ohio.

The occurrence of this brood in 1845 and 1862 is well remembered by several of my correspondents and is recorded by Dr. Smith. At Saint Joseph, in Buchanan County, Missouri, Cicadas were not so thick in 1862 as in 1861. Had it been the reverse, or, in other words, had they been more numerous in 1862 than in 1861, I should have been inclined to record the visit of 1861 as but a precursor to this Brood X; but as it is, I believe the two broods are distinct, and that they occur for two consecutive years both in central Ohio and in portions of northwestern Missouri.

This brood has not been traced further east in Missouri than Saline County, and

yet a detachment of it certainly occurs in Ohio, for Mr. Clarke Irvine, of Oregon, Holt County, Missouri, well remembers their occurrence in central Ohio in 1845 and 1862. Though there is no knowledge of the appearance of this Brood XIV in Illinois, yet the fact of its occurring both in Ohio and in northern Missouri, and that, too, but one year after Brood XIII, would indicate that there may have been in times past, at all events, if there is not at the present day, a geographical connection between these two broods.

1879.—This brood was well recorded in 1879 from Missouri and especially Kansas, while reports from other States give it a much wider extension in the trans Mississippi States than was previously recorded.

The reports from Missouri do not add anything new, since they all come from the northwestern portion of the State, where the brood was already by well-established previous visits, and I would only mention that, according to Mrs. Barbara M. Shiesl (letter of June 16, 1879), Saint Joseph belongs to those cities which have had this brood within their limits.

In Kansas the extent of the brood has been studied by our trusted correspondent Mr. Robert Milliken, of Emporia, who wrote me as follows on June 22, 1879: "I have been at some little trouble to inquire regarding the extent of the distribution of the *Cicada septendecim* in this State at the present, and learn that it is general throughout the central counties. I have positive information of their occurrence in Lyon, Morris, Chase, Marion, Greenwood, Coffey, Osage, and Woodson Counties, wherever there are belts of timber." The following reports refer to localities in Kansas not mentioned by Mr. Milliken: Mr. J. Paulsen, Fort Scott, Bourbon County (card of June 16, 1879), states that they were in great numbers at his place, injuring apple trees. From the same county they are reported by Mr. G. C. Willey, of Uniontown (letter of June 20, 1879), stating that the Cicadas are in the timber skirting the streams in his county, and that "their number is beyond the comprehension of man." Mr. J. F. Willard (card of June 20, 1879) briefly recorded them from near Alma, Wabaunsee County, and near Louisville, Pottawatomie County. Mr. M. J. Burdge (card of June 25, 1879) stated that the Cicadas made their appearance in the timber along the streams in Johnson County. Finally, Mr. J. C. Harrun, of Humboldt, Allen County, wrote (June 14, 1879): "There are great numbers of the Cicadas along the Neosho and other rivers, in the timber belts, and a few have found their way to the hedges on the prairies." It will be seen that these localities form a nearly compact region in the eastern third of Kansas, and there can hardly be any doubt that this brood occupies also the extreme northern and southern counties in the same section of the State.

The northernmost point reached by this brood, so far as now established, appears to be Pottawattamie County, Iowa, in which State, according to Prof. C. E. Bessey (*vide* his map in the *Amer. Entom.*, III, p. 27), it occupies the eight counties comprising the southwestern corner of the State.

Across the Missouri River the brood extends into Nebraska, as on June 19, 1879, I received from Mr. D. W. Hershey specimens captured at Nebraska City.

From Arkansas reports for 1879 are wanting, but from trustworthy testimony we have to add Indian Territory and northern Texas to the region occupied by this Brood XIV. From Indian Territory Mr. W. S. Robertson, Muscogee Post-Office, sent me specimens captured near the banks of the Arkansas River, and stated in his letter of June 17, 1879, "that this brood is entirely confined to the river bottoms, whereas another brood appears on the oak and hickory groves on the upland." Unfortunately, Mr. Robertson failed to give any dates for this upland brood, but it may possibly be Brood XVIII. The occurrence of the brood in northeastern Texas is based upon a letter from Mr. S. R. Ludlow, of Valley Creek, Fannin County, dated June 25, 1879, and stating that the Seventeen-year Cicadas made their appearance in the "brush section" of his county about April 20.

Future observations will no doubt add many other locations for this brood in Indian Territory and Arkansas, and thus connect more closely the southernmost point of the brood in Texas with the region occupied in Missouri and Kansas.

Leaving out of consideration the detached locality in central Ohio, which has not been confirmed in 1879, and which is based solely upon the testimony of Mr. Clarke Irvine, we see that this brood occupies a very compact region of the country, its southernmost point being about in the same latitude as that reached by Brood XXII in Northern Georgia.

BROOD XV.—*Septendecim*—1880, 1897.

In the year 1880, and at intervals of 17 years thereafter, they will, in all probability, appear from western Pennsylvania to Scioto River east, and down the valley of the Ohio River as far as Lewis County, in Kentucky.

This brood is recorded in Ohio as far back as the year 1812, by "A. M. B.," writing to the *Chicago Tribune*, under date of June 22, 1868. Harris also records its appearance in Ohio in 1829, and they were quite numerous in the center of the same State in 1846, or during the first year of the Mexican war; while Dr. Smith records it in the eastern part of the State, extending over twelve counties west to the Scioto River, and to Sandusky, on Lake Erie, in 1829, 1846, and 1863, and in Lewis County, Kentucky, since 1795. As before stated, this brood occurred in Ohio in 1846, simultaneously with the *tredecim* Brood VII in southern Illinois. Dr. Fitch, in his account of his fifth brood, also records its appearance, and states that it reached to Louisiana. But just as the *septendecim* Brood VIII was confounded with the great *tredecim* Brood XVIII in 1855, so this *septendecim* Brood XV was doubtless also confounded with it in 1829, for they both occurred that year. Had the western country been as thickly settled in 1829 as it was in 1855, the *tredecim* Brood XVIII could undoubtedly have been traced in southern Illinois and Missouri, &c., in the former as it was in the latter year. This belief is furthermore greatly strengthened from our having no other record of the appearance of this *septendecim* brood in Louisiana than Professor Potter's statement that they appeared there in 1829; whereas they have occurred there since 1829 at intervals not of 17 but of 13 years, and were there the present year [1868], as will be seen on referring to Brood XVIII. The dividing line of these two broods (XV and XVIII) is probably the same as with Broods VIII and XVIII.

Since the publication of the above I have received the following interesting communications regarding this brood: Mr. J. H. Niles, of Havana, Huron County, Ohio (letter of June 7, 1877), writing about the distribution of Broods XV and XXII, says: "I am acquainted with two distinct families of the Cicada in northern Ohio. I first saw the great eastern Ohio family [XV], due in 1880, in 1846, and again in 1863; and the small family [XXII], due in 1885, in 1834, again in 1851, and again in 1868. When the Cicada appeared in 1846, the question was raised whether they were partial to any particular geological formation. The result showed that they occupied the conglomerate, the sandstone, and the slatestone formations of eastern Ohio, not the limestone formation of western Ohio. For instance, a line drawn for the western edge of the black slate, from the city of Bucyrus, in Crawford County, and the northwest corner of Huron County and Erie County, to the east of Sandusky Bay, marked correctly the western edge of the Cicada of 1880."*

An important contribution to our knowledge of the extent of this brood was furnished by the following letter from Mr. Luther Haymond, of Clarksburg, Harrison County, West Virginia, dated June 1, 1877: "The Seventeen-year Cicada appeared in this district as follows: On the 12th May, 1795; on the 25th May, 1812; on the 25th May, 1829; on the 15th May, 1846; on the 25th May, 1863. I am not certain as to the extent of this Cicada district, but I think it includes all of West Virginia lying on the west side of the Alleghany Mountains."

1880.—The reappearance of this brood in Pennsylvania and Ohio was generally noted in the papers, without, however, conveying any new or important information. The *New York Weekly Tribune* of June 7, 1880, contains an article commencing, "The seventeen-year locust is filling the hills and rich bottom lands of western Pennsylvania and Virginia with its droning thunder," &c. Since this brood has never been observed east of the Alleghanies, its occurrence in Virginia is extremely improbable, and the author of the article apparently intended to write "West Virginia." Several of my own correspondents reported the brood from Geauga and Lake Counties, Ohio, and Mr. William H. Edwards, of Coalburg, W. Va., wrote that the Cicada had appeared in his section of West Virginia (*Amer. Entom.*, III, p. 170), thus confirming Mr. Haymond's statement given above.

Thus the brood, so far as now ascertained, occupies a very compact area, comprising western Pennsylvania, western West Virginia, the whole eastern half of Ohio, and adjacent portions of northern Kentucky.

There do not seem to be any well-established detached localities for this brood, and the only indication of any such locality is contained in the article by Professor Bessey referred to under Brood XIII (*Amer.*

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* The continuation of this letter, relating to Brood XXII, will be found under that brood.

Entom., III, p. 29), where he says: "Mr. Meredith, a member of the senior class of the Agricultural College, and a resident of Taylor County, informs me that there were no Cicadas in that county this year, but that *they were there in* 1863. He says he 'is certain as to the last date.' Unless there is some mistake in this, we have here a small area of a third brood—Professor Riley's Brood No. XV."

Professor Bessey himself classed this report among the doubtful ones, and it will be best not to adopt it without further corroborative testimony.

BROOD XVI.—*Tredecim*—1880, 1893.

In the year 1880, being the same as the preceding, they will, in all probability, appear in the northern part of Cherokee County, Georgia, having appeared there, according to Dr. Smith, in 1828, 1841, 1854, and, according to Dr. Morris, in 1867. This brood occurred in 1867 simultaneously with the northern *septendecim* Brood XXI.

Like the other broods recorded from northern Georgia, this Brood XVI has since remained without confirmation. It seems difficult to get information on the appearance of the Cicada in that portion of the country, which on account of the interlocking and overlapping of several broods there, is of especial interest and importance in a correct chronology. I would especially urge correspondents from that region to send me data.

BROOD XVII.—*Septendecim*—1881, 1898.

In 1881, and at intervals of 17 years thereafter, they will, in all probability, appear in Marquette and Green Lake Counties, in Wisconsin, and may also appear in the western part of North Carolina and about Wheeling, W. Va., in northeast Ohio, and a few in Lancaster County, Pennsylvania, and Westchester County, New York.

There is abundant evidence that they appeared in the counties named in Wisconsin in 1864, and fair evidence that they appeared that year in Summit County, northeastern Ohio, while straggling specimens were found in the same year by Mr. S. S. Rathvon, in Lancaster County, Pennsylvania, and by Mr. James Angus, in Westchester County, New York. Dr. Fitch also records their appearance in 1847, or 17 years previously, in the western part of North Carolina, and Dr. Smith in Wheeling, W. Va., in 1830, 1847, and 1864. The distance between the localities given is very great, and it is doubtful whether all these records belong to one and the same brood.

1881.—The more southern localities given for this brood, viz., North Carolina and West Virginia, remained unconfirmed, and are thus rendered even more doubtful now than they were when I wrote the above, in 1868. I have also no further records from northeastern Ohio, but from the remaining States confirmatory reports were received in 1881. From Wisconsin, Dr. J. A. Renggly, of La Crosse (letter of October 20, 1881), records the appearance of the Cicada in La Crosse County; and J. W. Wood, of Baraboo (letter of June 28, 1881), stated that they were abundant in 1881 in Sauk County, and still more abundant in 1864. From New York State they were reported by Mr. William T. Davis, of Tompkinsville (letters of June 24 and July 6, 1881), who observed the Cicadas on Staten Island; and from this locality they seem to extend into

New Jersey, as Mr. M. S. Crane, of Caldwell, Essex County, found specimens near his place on May 30. In his letter of August 3, 1881, he says: "Several days before May 30 I had heard their shrill a few times, and an occasional one was heard for a week or so afterward." In Pennsylvania they were observed in small numbers near Germantown by Mr. Henry C. Haines (letter of June 24, 1881). In the eastern States this brood evidently does not appear in very numerous swarms, the main body being apparently in Wisconsin and perhaps farther west. That this brood occurs west of Wisconsin is rendered very probable by the following communication by James C. Merrill, captain and assistant surgeon, U. S. A., from Fort Custer, Montana Territory, dated July 11, 1881: "During a collecting trip to the Big Horn Mountains, early in June, I found the Cicada extremely abundant on the northern slope of this range. They were most common at a height of about 4,500 feet, thence upwards about 1,500 feet to the lower growths of pines, where a few only were found. Their favorite resorts were in patches of cherry brush, each little bush having from two or three to a dozen or more Cicadas upon it; and in riding through such places the noise of these insects was almost deafening. They do not appear to occur far from the mountains, even along the streams flowing out. They were observed on both sides of the Montana-Wyoming line. Their presence seems to be appreciated by the trout, which would refuse even their favorite grasshoppers for the Cicada."

Brood XVIII.—*Tredecim*—1881, 1894.

In the year 1881, and at intervals of 13 years thereafter, they will, in all probability, appear in southern Illinois, throughout Missouri, with the exception of the northwestern corner, in Louisiana, Arkansas, Indian Territory, Kentucky, Tennessee, Mississippi, Alabama, Georgia, and North and South Carolinas.

Though, as already stated, I published the first account ever given of the existence of a 13-year brood,* yet, besides the others mentioned in this chronology, this particular brood has been traced since as having occurred in the years 1816, 1829, 1842, 1855, and 1868; and Mr. L. W. Lyon, at the July (1868) meeting of the Alton (Ill.) Horticultural Society, even mentioned its appearance in 1803.

In Missouri it occurs more or less throughout the whole State, with the exception of the northwest corner, that is bounded on the east by Grand River and on the south by the Missouri River.† The southeast part of the State, where Dr. Smith has recorded it since 1829, is most thickly occupied. I enumerate those counties in which there is undoubted evidence of their appearance during the present year (1868) viz: Audrain, Bollinger, Benton, Clark, Chariton, Callaway, Cooper, Cole, Franklin, Gasconade, Iron, Jefferson, Knox, Lewis, Marion, Macon, Morgan, Moniteau, Pike, Phelps, Pulaski, Polk, Pettis, Schuyler, Saint Charles, Saint Louis, Saint François, Saint Clair, Warren, and Washington.

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* See note, p. 5, for facts ascertained since the above was written.

†As Mr. William Kaucher, of Oregon, Holt County, saw a few individuals in the northeastern part of Buchanan County in 1855, it may occur in small numbers in districts even north of the Missouri River.

It not improbably overlaps some of the territory occupied by the *septendecim* Brood XIV, but I do not think it extends into Kansas.

In Illinois it occurs more or less throughout the whole southern half of the State, but more especially occupies the counties from the southern part of Adams County along the Mississippi to the Ohio, up the Ohio and Wabash Rivers to Edgar County, and then across the center of the State, leaving some of the central counties in southern Illinois unoccupied. To be more explicit, I enumerate all the counties in which it undoubtedly occurred during the present year (1868): Adams (south part, back of Quincy), Bond, Clinton (northwest corner, adjacent to Madison), Champaign, Coles, Crawford, Cumberland, Clay, Clark, Edwards, Edgar* (especially in the eastern part), Franklin, Gallatin, Hardin, Hamilton, Johnson, Jasper, Jersey, Jefferson, Lawrence, McLean (east end), Macon, Madison, Marion, Massac, Monroe, Pike, Perry, Piatt, Pope, Richland, Randolph, Sangamon, Saline, Saint Clair, Union (northeast corner), Washington, Wayne, Wabash, Williamson, and White. There were none the present year either at Decatur, in Macon County, or at Pana, in Christian County; nor were there any at Bloomington or Normal, in McLean; nor in Dewitt County, which lies south of McLean; nor in Spring Creek, Iroquois County, which is northeast of Champaign

In Kentucky, according to Dr. Smith, it occurred in the northwest corner of the State, about Paducah and adjacent counties south, in 1829, 1842, and 1855, and it occurred there in 1868.

In Arkansas it occupied all the northern counties in 1842, 1855, and 1868.

In Alabama it occupied Russell and adjacent counties on the east side of Black-Warrior River in 1842, 1855, and 1868.

In Tennessee it occupied Davidson, Montgomery, Bedford, Williamson, Rutherford, and adjacent counties in 1842, 1855,† and 1868.

In North Carolina it appeared in Mecklenburg County in 1829, 1842, 1855, and 1868.

In South Carolina, the Chester district, and all the adjoining country to the Georgia line west and to the North Carolina line north, was occupied with it in 1816, 1829, 1842, 1855, and 1868.

In Georgia it has occurred in Cherokee County since the year 1816.

In Louisiana it appeared in Morehouse, Caddo, Claiborne, Washington, and adjacent parishes in 1855 and 1868.

It also doubtless occurs in Mississippi and Indian Territory, though I am unable to specify any localities.

1881.—This is not only by far the largest 13-year brood, but also one of the best known of all recorded broods, as can be readily seen from the numerous localities where it was observed in 1868 and at previous visits. Its reappearance in 1881 was equally well observed and recorded, and the communications received and the other dates collected that year nearly equal in number those received since 1868 relating to the other twenty-one broods combined.

In Missouri and Illinois its localities are so well known and established in the above-quoted account that it would be superfluous to give here in detail the numerous confirmatory reports of 1881 which I have from nearly every county mentioned above. In Illinois the extent of the brood was studied by Prof. S. A. Forbes, of Normal, and Mr. John C.

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* Edgar County also has the *septendecim* Brood III.

† Though Cicadas occurred in large numbers in Davidson County and other portions of Tennessee in 1855, and also in 1868, yet in Lawrence County they appeared in 1856, instead of 1855—another instance of a belated brood.

Andras, of Manchester, and upon their authority Green and Morgan counties have to be added to the list.

From Kentucky I had no direct news in 1881, but they appeared there in that year, according to an article in the *Scientific American* for July 9, 1881. Specified localities are, however, not given.

In Arkansas the article just alluded to records them in large numbers at Little Rock, Fort Smith, and Hot Springs. Rev. W. C. Stout, of Hawkstone P. O., wrote me recording them from Conway County, and stating his knowledge of their appearance in 1842, 1855, 1868, and 1881. Mr. M. F. Markle, Hazen, Prairie County (letter of June 4, 1881), announces the appearance of the Cicadas at his place. Mr. J. J. Brown, in a communication to *Colman's Rural World*, January 1, 1873, states that the Cicada occupied that portion of northwestern Arkansas which is watered by White River and its tributaries, having appeared regularly every thirteen years since it was settled by the whites. From his own observations he traces them back to 1842, and believes "that they have been steadily decreasing in numbers for the past sixty-nine years, or since 1803."

Mr. John D. Wilkins, Selma, Ala., took particular pains to ascertain the extent of the brood in Alabama, and, as the result of his inquiries and observations, he wrote me, July 11, 1881, that the Cicadas occupied that year the central and northern portions generally, notably Dallas, Perry, Lowndes, Montgomery and Blount Counties and adjacent districts, and that they were most abundant in the northern period. Other confirmatory reports were received from the counties mentioned by Mr. Wilkins, while, according to the *Scientific American* of July 9, 1881, they extended in Alabama as far south as Mobile.

In Tennessee they were observed in 1855 and 1868 in the vicinity of Nashville by Mr. William Prichard, of that place (letter of January 5, 1873), and Mr. George McKnight, of Yorkville, Gibson County, stated, in a letter of April 23, 1881, that in 1868 the Cicadas appeared generally throughout middle Tennessee.

In Georgia, Mr. John Murphy, of Fairburn, Campbell County (letter not dated), observed them in his county in 1842, 1855, and 1868, and they appeared also, according to D. C. Sutton, in 1868, in Walker County and the northwestern part of the State in general.

From North Carolina Mr. Calvin J. Cowles, of the United States assay office at Charlotte, was kind enough to furnish the following data on the distribution of the Cicada in 1881 (letter of April 28, 1882): "They were here [at Charlotte], and they were in Iredell County, extending from a point a few miles west of Statesville to the Alexander and Wilkes County line, and running over so as to embrace the Brushy Mountain section to a point 8 miles southeast of Wilkesboro', and on up the range of mountains to the vicinity of Lenoir, in Caldwell County."

In South Carolina Mr. Henry Trescott, of Pendleton, Anderson

County, observed the Cicadas in 1881 in Anderson, Oconee, and Pickens Counties.

From Louisiana no information has reached me since 1868, and the same holds true of Indian Territory, but I have no doubt that the "upland brood" alluded to by Mr. W. S. Robertson, of Muscogee P. O., in connection with Brood XIV (*vide* p. 33), must be referred to this Brood XVIII.

Mississippi, as I suspected in 1868, must be added to the States in which this brood occurs, as it was observed in 1881 at Kirkwood, Madison County, by Dr. E. H. Anderson (letter of May 3, 1881).

The State of Virginia must also be added to the vast region occupied by this brood, since Mr. Calvin J. Cowles, of Charlotte, N. C., says in his letter referred to above: "They were published as being noisy and numerous in Prince George County, Virginia." This county is in the southeastern portion of the State.

A most interesting and quite unexpected addition to our knowledge of this brood is contained in the following letter from Dr. B. F. Kingsley, acting assistant surgeon, United States Army, of Fort Quitman, El Paso County, Texas, dated July 5, 1881:

"Having just read your very interesting letter to the *Tribune*, dated Washington, D. C., June 16, 1881, relative to Cicadas, I take pleasure in complying with your solicitation for reports from different sections, concerning the Cicada. About the 20th of May they made their appearance in this section in immense numbers. Every tree and bush from El Paso, Tex., to this point and below, a distance of over 100 miles, was literally alive with them. About two weeks ago they disappeared as suddenly as they came. Six weeks previous to the appearance of the Cicada the cottonwood trees in this valley (of which there are a great many) were covered with a species of caterpillar, which rapidly disappeared upon the advent of the Cicada. The arrival of one and departure of the other seem to have been simultaneous. What, if any, the connection was, I am unable to say; * perhaps only a coincidence. I cannot say whether the Cicadas were confined to the valley, or were equally as widespread over the prairie."

These Cicadas along the extreme western boundary of Texas belong, without question, to this Brood XVIII, which thus occurs in every one of the Southern States, except Florida,† and also in the adjacent portions of some of the more northern States. Its occurrence in the Rio Grande Valley even renders it quite probable that it occurs in New Mexico and Mexico, and it will probably be found to extend along the bottom woods of the upper Colorado, Brazos, and other rivers in Texas.

* There is of course no connection whatever between this caterpillar, whatever species it may have been, and the Cicada.

† The Periodical Cicada does not seem to extend into the peninsula of Florida; in fact, with the exception of the extreme northwestern corner, no broods have ever been observed in that State.

BROOD XIX.—*Septendecim*—1882, 1899.

In the year 1882, and at intervals of seventeen years thereafter, they will, in all probability, appear in Monroe, Livingston, Madison, and adjacent counties, and around Cayuga Lake, in New York.

Mr. T. T. Southwick, of Manlius, Livingston County, records their appearance there in 1865, and, as will be seen by referring to the *Prairie Farmer*, vol. 16, p. 2, they appeared during the same year near Cayuga Lake, while Dr. Smith records their appearance in 1797, 1814, 1831, and 1848.

In addition to the above recorded data, I received a communication from Mr. T. E. Hayward, of Pittsford, Monroe County, New York, dated February 13, 1878, in which he speaks of this brood as follows:

"It lies wholly on the east side of the Genesee River, and is bounded by Lake Ontario on the north and probably Cayuga Lake on the east, and extends south 40 or 50 miles to the pine region. You are well aware that it occupies the oak and hickory portions only, and of course there are whole townships within this space where it is scarcely known. This is the 17-year kind, and the first appearance I saw was in 1831, the next in 1848, and again in 1865, and of course they will put in an appearance in 1882, the very year left blank by all the broods then known to exist."

1882.—In this year the reappearance of the brood was communicated to me by Mr. Simon Forshay, of Penn Yan, Yates County, New York (letter of July 10, 1882), and the same correspondent furnished later (letter of October 9, 1882) the following data: "My means to obtain data in this Cicada matter are quite limited, and therefore I can only furnish you with the following: There are two districts in this county (Yates), the towns of Forrey and Middlesex, where these Cicadas were prevalent in great numbers during a part of June and July. Their extent in Forrey covered an area of about four square miles, and in Middlesex somewhat less. These towns or localities are situated at some distance from each other, one bordering on Seneca Lake and the other on Canandaigua Lake. I am also informed that these insects were prevalent in portions of the counties of Ontario, Livingston, and Wyoming, of western New York. I am not able to learn that they made their appearance in any other parts of the State."

While there cannot be the least doubt as to the genuineness of this brood, its small extent, covering only a few counties in a single State, is certainly noteworthy. It is a mere local swarm when compared with most other well-established broods of the 17-year race, and other similar swarms of still smaller extent can no doubt be traced in various parts of the country; for I have a number of communications testifying to the appearance of the Cicada in restricted localities which cannot be referred to any of the established broods, not even as precursors or belated specimens. It would be premature to establish for every one of these locally restricted swarms a new brood, based as they are upon a single record, and their consideration is therefore deferred until more material has accumulated for a thoroughly revised chronology.

BROOD XX.—*Septendecim*—1883, 1900.

In the year 1883, and at intervals of seventeen years thereafter, they will, in all probability, appear in western New York, western Pennsylvania, and eastern Ohio. In the last mentioned State they occur more especially in Mahoning, Carroll, Trumbull, Columbiana and adjacent counties, overlapping, especially in Columbiana County, some of the territory occupied by Brood XV. In Pennsylvania they occupy nearly all the western counties, and their appearance is recorded in 1832, 1849, and 1866, by Dr. Fitch (his second brood), Dr. Smith, and several of my correspondents, the following counties being enumerated: Armstrong, Clarion, Jefferson, Chemung, Huntingdon, Cambria, Indiana, Butler, Mercer, and Beaver.

1883.—This is one of the smaller broods which does not seem to have attracted much attention in 1883. Only two communications of a positive character regarding its reappearance in that year have reached me, both of them from Pennsylvania. Mr. J. S. Elder, of Darlington, Beaver County, wrote me, June 7, 1883: "I heard the 17-year Cicada this morning for the first; they were expected this year," and Dr. J. M. Toner also brought me, on June 16, 1883, specimens from New Derry, Westmoreland County, stating at the same time that he had known them in 1832, 1849, and 1866 in the same locality. Some time in the earlier part of July, 1883, an item appeared in the *New York Herald* stating that "a swarm of locusts" is doing much damage in Chautauqua County, New York. I wrote for further information to Mr. Newel Cheney, of Poland Centre, of that county, but after careful inquiries he failed to confirm the statement.

The appearance of the Cicadas in 1866 in northwestern Pennsylvania was verified by several correspondents, notably by Mr. J. C. Hamm, now of Humboldt, Kansas.*

BROOD XXI.—*Septendecim*—1884, 1901.

In the year 1884, and at intervals of seventeen years thereafter, they will, in all probability, appear in certain parts of North Carolina and central Virginia. In 1850 and 1867 they appeared near Wilkesboro', N. C., and were also in central Virginia during the last mentioned year, while Dr. Smith mentions them as occurring in Monroe County and the adjacent territory in West Virginia in 1833 and 1850.

Dr. Harris (Inj. Insects, p. 210) records their appearance at Martha's Vineyard, Massachusetts, in 1833, but as I cannot learn that they were there, either in 1850 or 1867, I infer that Dr. Harris's informant was mistaken.

1884.—In the year 1883 I received through the Smithsonian Institution specimens from Loudoun County, Virginia, and these were doubt-

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* Whether the following letter, dated August 2, 1883, which we received from Mr. O. C. Mortson, of Clendenin, Meagher County, Montana, refers to the Periodical Cicada or to another species of Cicada cannot be definitely determined, as I received no specimens. I simply quote it in order to draw attention to the possibility of a brood of the Periodical Cicada occurring in western Montana: "The 17-year locust has made its appearance in large numbers on the south timbered slope of the Judith Basin, also near Missoula on the headwaters of the Columbia River. The insect I know to be a Cicada, as it is three-fourths of an inch long, with wings 1¼ to 1¾ inches long, with tissues forming a W, and when jumping past you sounds almost like a rattlesnake. They hatched out about July 13, and are still here."

less forerunners of this Brood XXI. On account of my absence in Europe I obtained no further data in 1884 for the more southern localities, but for Martha's Vineyard Prof. C. E. Bessey published the following note in the *American Naturalist*, October, 1883: "While driving across 'the plains' of the central part of Martha's Vineyard, Massachusetts, in the last few days of June of this year, I observed large numbers of the Periodical Cicada (*Cicada septendecim*). The scrub oaks, which here cover the whole ground, were literally alive with them. Specimens of twigs containing eggs were secured, as also of the insects themselves and their abandoned pupa skins. * * * The insects were confined to a narrow belt not exceeding half or three-quarters of a mile in width and of unknown length, and possibly this may account for the fact that the inquiries referred to above failed to elicit any knowledge of previous visitation. Supposing Dr. Harris to be right, we have here a slight acceleration in development, due probably to the well-known milder climate of the island." In the editorial remarks to this note I considered this limited appearance on Martha's Vineyard as precursive to Brood XXI, but there is yet some doubt about its real position.

Brood XXII.—*Septendecim*—1868, 1885.

In the year 1885, and at intervals of seventeen years thereafter, they will, in all probability, appear on Long Island; at Brooklyn, in Kings County, and at Rochester, in Monroe County, New York; at Fall River, and in the southeastern portion of Massachusetts; in Rutland County, Vermont; in Pennsylvania, Maryland, District of Columbia, Delaware, and Virginia; in northwestern Ohio, in southeastern Michigan, in Indiana, and Kentucky.

This brood has been well recorded in the East in 1715, 1732, 1749, 1766, 1783, 1800, 1817, 1834, 1851, and 1868. It is spoken of in *Hazzard's Register* for 1834, published in Philadelphia, while Mr. Rathvon has himself witnessed its occurrence during the latter four periods in Lancaster County, Pennsylvania.

It is the fourth brood of Dr. Fitch, who only says that it "reaches from Pennsylvania and Maryland to South Carolina and Georgia, and what appears to be a detached branch of it in the southeastern part of Massachusetts." He is evidently wrong as to its occurring in South Carolina and Georgia, and it is strange that he does not mention its appearance in New York, for Mr. F. W. Collins, of Rochester, in that State, has witnessed four returns of it there, namely, in 1817, 1834, 1851, and 1868, while the Brooklyn papers record its appearance there the present season (1868). As these two points in the State are about as far apart as they well can be, the intervening country is probably more or less occupied with this brood.

Mr. H. Rutherford, of Rutland County, Vermont, records their appearance in that neighborhood in 1851 and 1868. (*New York Semi-Weekly Tribune*, June 27, 1868.) He also witnessed them in the same place in 1855, and, as will be seen by referring to Brood XVIII, they also occurred on Long Island and in southeastern Massachusetts in that same year, 1855. Exactly thirteen years intervening between 1855 and 1868, one might be led to suppose that they had a *tredecim* brood in the East. But did such a brood exist, it would certainly have been discovered ere this, in such old settled parts of the country, and all the records go to show that they have nothing but *septendecim* there. By referring to Brood VIII, the mystery is readily solved, for we find that in that part of the country there are two *septendecim* broods, the one having last appeared in 1855, the other the present year, 1868.

In Ohio, the brood occurred more or less throughout the whole western portion of the State, for our correspondents record them as having appeared in 1868 in Lucas and Hamilton and several intervening counties. Mr. F. C. Hill, of Yellow Springs, in Greene County, southwestern Ohio, has witnessed their appearance in 1834, 1851, and 1868, and they occurred in the northwestern part of the State during the three same years; while the correspondent to the Department of Agriculture, from Toledo, northwestern Ohio (July, 1868, Monthly Report), says it is their ninth recorded visit there. Dr. Smith records it as occurring around Cincinnati, and in Franklin, Columbiana, Pike, and Miami Counties.

In Indiana there is reliable evidence of their appearance in 1868 in the southern part of the State, in Tippecanoe, Delaware, Vigo, Switzerland, Hendricks, Marion, Dearborn, Wayne, Floyd, and Jefferson Counties. The evidence seems to show that, as in Ohio, throughout the State, they belong to the *septendecim* Brood XXII, for Mr. F. Guy, of Sulphur Springs, Mo., has personally informed me that they were in southern Indiana in 1851, and even in Tippecanoe County, on the Wabash River, where, from their proximity to Brood XVIII, one might have inferred them to be *tredecim;* they are recorded as appearing in 1834 and 1851.

In Kentucky they appeared around Louisville. In Pennsylvania, Maryland, Delaware, and Virginia the territory occupied by this brood is thus described by Dr. Smith: "Beginning at Germantown, Pa., to the middle of Delaware; west through the east shore of Maryland to the upper part of Anne Arundel County; thence through the District of Columbia to Loudoun, West Virginia, where it laps over the South Virginia district (see Brood XII) from the Potomac to Loudoun County, some 10 or 12 miles in width, and in this strip of territory Cicadas appear every eighth and ninth year. Thence the line extends through the northern counties of Virginia and Maryland to the Savage Mountains, and thence along the southern tier of counties in Pennsylvania to Germantown.

Since the above was published, seventeen years ago, I have received reliable testimony to the effect that Dr. Fitch may, after all, be right in extending this brood as far south as Georgia, as will be seen by referring to the notes to Brood II, and it is to be hoped that this year's (1885) observations may definitely settle this interesting point. The counties in Georgia where the appearance of the Cicada may be looked for this year are those of the extreme northwestern corner, and more especially Habersham County.

Otherwise the notes I have since received do not alter the boundaries of this brood as given above. In 1868 the Cicadas appear to have been extremely numerous in the city of Germantown, Pa., as will be seen from the following extract from a letter we received on June 6, 1881, from Mr. John B. Wood, of that city: "In the year 1868 my wife being sick nearly all summer she was very much disturbed by what we called 17-year locust. They seemed to come up out of the ground from under the pine trees, but preferred climbing up a large pear tree, going out to the end of the branches and stinging the pears. They were in thousands, some of them roaring out and others replying to them, making a fearful din, which we were powerless to overcome. The ground around this pear tree, and a few pines covering a section of land, I should say 20 or 30 feet square, was fairly riddled with their holes. All around here they appeared in this way in spots, but filling the air with their racket. They were in full blast by the 19th of June." The

inhabitants of Lancaster, Pa., will also have the opportunity this year of listening to the music of the Cicadas within the limits of their city, as Mr. S. S. Rathvon saw them abundantly at that place in 1868.

The late F. S. Sleeper, of Galesburg, Kalamazoo County, furnished me the following interesting statement regarding the distribution of the Cicada in his county: "During 1868 they appeared in great numbers in this locality, being confined to a narrow strip about four miles in width through the northern part of this county. In this strip the ground was fairly honeycombed in appearance where they came up. There were some scattering ones out of this strip. My mother states that they were very abundant seventeen years previous (1851)."

Regarding the extent of this brood in northwestern Ohio and the dividing line between this and Brood XV, compare the letter of Mr. J. H. Niles, of Havana, Huron County, Ohio, which I quoted on p. 34. In the same letter Mr. Niles continues as follows: "Five miles west of this dividing line, in the northeast corner of Seneca County and the adjoining corner of Sandusky County, is located the brood of 1885. They occupy only some 30 square miles, and are on a cluster of ridges of the ancient lake coast deposit, overlaying the limestone soils."

This is the largest 17-year brood on record, and although it does not appear to reach the Mississippi River it certainly equals in extent the largest 13-year Brood XVIII, both broods having appeared simultaneously in the year 1868. In the more northern States this Brood XXII appears to be broken up in several isolated detachments, while its southern extension, viz., from North Carolina to northern Georgia, is not yet established as fully as might be desired.

SUMMARY OF DISTRIBUTION AND FUTURE APPEARANCE.

Summing up the distribution of the Periodical Cicada (both 17- and 13-year races) within the United States, as specified in the above enumeration of the different broods, it will be seen that the Cicada is known to occur in all the States east of the plains excepting the northern portion of New England, northern Michigan, and the whole of Minnesota. It thus appears that this Cicada does not breed in those northern States or portions thereof in which the woods are composed more or less exclusively of pine trees or other conifers. Rhode Island possesses no broods so far as we know, but this may be due to want of proper records, as several broods reach close to the borders of that State. Neither does the species occur in the peninsula of Florida, for reasons either of a climatic or geologic nature. Our knowledge of the western extent has greatly increased since 1868, and several broods can now be traced as far west as eastern Montana and Wyoming, central Colorado, and the extreme western parts of Texas, while less reliable evidence even indicates (*vide* Brood XX) that the species may occur in western Montana along streams emptying into the Pacific Ocean. Unless this report

be substantiated in future the distribution will not extend beyond the dividing range of the Rocky Mountains. The connection between the distribution of this insect and the botanical, geological, and topographical characteristics of the country forms a very interesting subject for consideration, and I hope to consider it in a future edition of this Bulletin.

The following summaries may be made, for convenience, from the foregoing chronological account, the Roman numerals indicating the number of the brood, and the asterisk the 13-year broods.

During the next seventeen years there will occur broods of the Periodical Cicada somewhere or other in the United States, in the following years:

1885. VII* and XXII.
1886. I.
1888. V and X*.
1889. VIII.
1891. IX.
1893. XI and XVI*.
1894. XII and XVIII*.
1895. II* and XIII.
1896. IV* and XIV.
1897. VI* and XV.
1898. VII* and XVII.
1899. XIX.
1900. XX.
1901. X* and XXI.

Thus every year except 1887, 1890, and 1892, will, during the next seventeen years, be somewhere a Cicada year; and it will be noticed that the 13-year broods invariably concur with some 17-year brood, a fact which is worthy of note and which leads to interesting speculation as to the origin of the former.

It further appears that the number of distinct broods appearing in different years within the same geographical limits are as follows:

ALABAMA.—Two broods; years 1894 [XVIII*] and '96 [IV*], and probably another in 1888 [X*].

ARKANSAS.—Two broods; years 1885 [VII*] and '94 [XVIII*].

COLORADO.—One brood; year 1891 [IX].

CONNECTICUT.—Two broods; years 1886 [I], and 1894 [XII].

DELAWARE.—Two broods; years 1885 [XXII] and '89 [VIII].

DISTRICT OF COLUMBIA.—Two broods; years 1885 [XXII] and '94 [XII].

FLORIDA.—One brood; year 1896 [IV*].

GEORGIA.—Five broods; years 1885 [two broods VII* and XXII], '93 [XVI*], '94 [XVIII*], and '95 [II*].

ILLINOIS.—Six broods; years 1885 [VII*], '88 [V], '89 [VIII], '93 [XI], '94 [XVIII*], and '95 [XIII].

INDIAN TERRITORY.—Two broods; years 1894 [XVIII*] and '96 [XIV].

INDIANA.—Five broods; years 1885 [XXII], '88 [V], '89 [VIII], '93 [XI], and '94 [XII].

IOWA.—Two broods; years 1888 [V] and '95 [XIII].

KANSAS.—Two broods; years 1885 [VII*] and '96 [XIV].

KENTUCKY.—Three broods; years 1885 [XXII], '89 [VIII], and '94 [XVIII*].

LOUISIANA.—Three broods; years 1885 [VII*], '94 [XVIII*], and '97 [VI*].

MARYLAND.—Four broods; years 1885 [XXII], '89 [VIII], '93 [XI], and '94 [XII].

MASSACHUSETTS.—Four broods; years 1885 [XXII], '86 [I], '89 [VIII], and 1901 [XXI].

MICHIGAN.—Two broods; years 1885 [XXII] and '88 [V].

MISSISSIPPI.—Four broods; years 1885 [VII*], '94 [XVIII*], '96 [IV*], and '97 [VI*].

MISSOURI.—Four broods; years 1885 [VII*], '94 [XVIII*], '95 [XIII], and '96 [XIV].

MONTANA AND WYOMING.—One brood; year 1898 [XVII].

NEBRASKA.—Two broods; years 1891 [IX] and '96 [XIV].

NEW JERSEY.—Two broods; years 1889 [VIII], and '94 [XII].

NEW YORK.—Five broods; years 1885 [XXII], '89 [VIII], '94 [XII], '99 [XIX], and 1900 [XX].

NORTH CAROLINA.—Seven broods; years 1885 [XXII], '89? [VIII], '93 [XI], '94 [two broods XII and XVIII*], '98? [XVII], and 1901 [XXI].

OHIO.—Seven broods; years 1885 [XXII], '89 [VIII], '95 [XIII], '96 [XIV], '97 [XV], '98 [XVII], and 1900 [XX].

PENNSYLVANIA.—Six broods; years 1885 [XXII], '88 [V], '89 [VIII], '94 [XII], '97 [XV], and 1900 [XX].

SOUTH CAROLINA.—Two broods; years 1885 [XXII] and '94 [XVIII*].

TENNESSEE.—Three broods; years 1885 [VII*], '94 [XVIII*], and '96 [IV*].

TEXAS.—Three broods; years 1888 [X*], '94 [XVIII*], and '96 [XVIII*].

VERMONT.—One brood; year 1885 [XXII].

VIRGINIA.—Four broods; years 1885 [XXII], '94 [two broods XII and XVIII*], and 1901 [XXI].

WEST VIRGINIA.—Four broods; years 1889 [VIII], '97 [XV], '98 [XVII], and 1901 [XXI].

WISCONSIN.—Two broods; years 1888 [V] and '98 [XVII].

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 9.

THE MULBERRY SILK-WORM;

BEING A

MANUAL OF INSTRUCTIONS

IN

SILK-CULTURE.

BY

C. V. RILEY, M. A., PH. D.

SEVENTH, REVISED EDITION.
WITH ILLUSTRATIONS.

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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 20, 1888.

SIR: The sixth edition of Bulletin No. 9 of this Division, on the Silkworm, having been exhausted, I have the honor to present for publication a seventh edition, which is little more than a reprint of the sixth, with such slight changes as late experience has suggested.

Respectfully,

C. V. RILEY,
Entomologist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.

PREFACE TO THE SECOND EDITION.*

That there exists just now a very general and widespread interest in the subject of silk-culture in the United States is manifest from the recent large increase in the correspondence of the Entomological Division in relation thereto, and from the demand made for this Manual. To avoid the disappointment that is sure to follow exaggerated and visionary notions on the subject, it may be well here to emphasize the facts that the elements of successful silk-culture on a large scale are at the present time entirely wanting in this country; that the profits of silk-culture are always so small that extensive operations by organized bodies must prove unprofitable where capital finds so many more lucrative fields for employment; that extensive silk-raising is fraught with dangers that do not beset less ambitious operations; that silk-culture, in short, as shown in this Manual, is to be recommended only as a light and pleasant employment for those members of the farmer's household who either can not do or are not engaged in otherwise remunerative work.

The want of experience is a serious obstacle to silk-culture in this country; for while, as is shown in the following pages, the mere feeding of a certain number of worms and the preparation of the cocoons for market are simple enough operations, requiring neither physical strength nor special mental qualities, yet skill and experience count for much, and the best results can not be attained without them. In Europe and Asia this experience is traditional and inherited, varying in different sections both as to methods and races of worm employed. With the great variety of soil, climate, and conditions prevailing in this country, experience in the same lines will also vary, but the general principles indicated in this Manual should govern.

The greater value of labor here as compared with labor in the older silk-growing countries has been in the past a most serious obstacle to silk-culture in the United States, but conditions exist to-day that render this obstacle by no means insuperable. In the first place, comparative prices, as so often quoted, are misleading. The girl who makes only twenty or thirty cents a day in France or Italy does as well, because

* This preface was written in 1882, and some passages are omitted which had only a temporary interest and which might be misleading to-day.

of the relatively lower prices of all other commodities there, as she who earns three or four fold as much here. Again, the conditions of life are such in those countries that every woman among the agricultural classes not absolutely necessary in the household, finds a profitable avenue for her labor in field or factory, so that the time given to silk raising must be deducted from other profitable work in which she may be employed. With us, on the contrary, there are thousands—aye, hundreds of thousands—of women who, from our very condition of life, are unable to labor in the field or factory, and have, in short, no means, outside of household duties, of converting labor into capital. The time that such might give to silk-culture would, therefore, be pure gain, and in this sense the cheap-labor argument loses nearly all its force. This holds more particularly true in the larger portion of the South and West, that are least adapted to the production of merchantable dairy products or where bee-keeping and poultry-raising are usually confined to the immediate wants of the household.

The want of a ready market for the cocoons is now, as it always has been, the most serious obstacle to be overcome, and the one to which all interested in establishing silk-culture should first direct their attention. Ignore this, and efforts to establish the industry are bound to fail, as they have failed in the past. A permanent market once established, and the other obstacles indicated will slowly, but surely, vanish as snow before the coming spring. Owing to the prevalence of disease in Europe, there grew up a considerable demand for silk-worm eggs in this country, so that several persons found the production of these eggs quite profitable. Large quantities are yet shipped across the continent from Japan each winter; but this demand is, in its nature, transient and limited, and, with the improved Pasteur method of selection and prevention of disease, silk-raisers are again producing their own eggs in Europe. Silk culture must depend for its growth, therefore, on the production of cocoons, and these will find no remunerative sale except where the silk can be reeled. I find no reason to change the views expressed relative to the part this Department might take in succoring silk-culture through Congressional aid; for, however just and desirable direct protection to the industry may be by the imposition of an import duty on reeled silk, no such protection has yet been given by Congress, and silk filatures can not be fully and profitably established without some fostering at the start. Under a heavy protective tariff our silk manufactures have rapidly grown in importance and wealth, until, during the year 1881 (according to the reports of W. C. Wyckoff, secretary of the Silk Association of America), raw silk to the value of $11,936,865 and waste silk and cocoons to the value of $769,186 were imported at the ports of New York and San Francisco, while our manufactured goods reached in value between $35,000,000 and $49,000,000. Now, the so-called raw silk thus imported to the value of nearly $12,000,000 is just as much a manufactured article as the woven goods,

and its importation free of duty is as much an encouragement to foreign manufacturers and an impediment to home industry as the removal of the duty would be on the woven goods. The aid that Congress, through this Department, should, in my judgment, give to silk-reeling, and thereby to silk-production, may be supplied by private and benevolent means.

*   *   *   *   *   *   *

The obstacles which I have set forth are none of them permanent or insuperable, while we have some advantages not possessed by other countries. One of infinite importance is the inexhaustible supply of Osage Orange (*Maclura aurantiaca*) which our thousands of miles of hedges furnish; another is the greater average intelligence and ingenuity of our people, who will not be content to tread merely in the ways of the Old World, but will be quick to improve on their methods; still another may be found in the more spacious and commodious nature of the barns and outhouses of our average farmers. Every year's experience with the *Maclura* confirms all that I have said of its value as silk-worm food. Silk which I have had reeled from a race of worms fed on it, now for eleven consecutive years, is of the very best quality, while the tests made at the recent silk fair at Philadelphia showed that in some instances a less weight of cocoons spun by *Maclura*-fed worms was required for a pound of reeled silk than of cocoons from mulberry-fed worms.

C. V. R.

WASHINGTON, D. C., *February* 20, 1882.

PREFACE TO THE SIXTH EDITION.

The growing interest shown in the culture of silk, in the United States, is attested by the demands upon this Department for copies of this manual, which has hitherto been published as Special Report No. 11. Originally prepared as a brief manual, based on my own experience of the industry in America, the present demands of silk-growers, or rather of those desirous of becoming such, call for some further details, and in elaborating the work it has been thought best to include it among the bulletins of the Division. I have also divided the matter into chapters, and those on the implements which are necessary to, or facilitate, the work; those on diseases, reproduction, reeling, and the physical properties of raw silk embrace essentially new material, parts of Chapters V and VI being from my current annual report not yet distributed.

In Chapter VIII, in speaking of machinery I have omitted the detailed descriptions of special machines given in former editions and explained rather the mechanical principles that should be involved in all. A description of the Serrell Reel would have been very appropriate, but the inventor has been promised by the Commissioner that such should not be made public until all patents are secured. I shall hope to elaborate this chapter in some future edition.

It must not be forgotten that the original manual was never intended as an extended treatise on silk-raising or reeling, but was prepared to give, in a simple and most condensed way, information to those interested, and in a form applicable to the United States. It is gratifying to know that a number of other pamphlets on the Silk-worm have of late years been published, and that this manual has been quite freely used in their preparation. In one instance, in fact, an almost verbatim copy has been published and sold privately. I have found little or no occasion to alter opinions expressed in the manual, but in the present edition have revised the estimates of profits given in the Introduction to the original edition, leaving out those on egg production, because of the changed conditions since 1879, which have rendered such work, as a profitable business, obsolete in this country, and the production of sound and reliable eggs much more difficult and expensive.

Though particular pains were taken to impress upon readers the fact that the estimates of profits in silk-raising were based on definite market prices at that time, and that prices and profits must needs, as in all trades, vary from year to year, and though I especially omitted the

cost of food, eggs, special buildings, etc., because the manual was addressed to those who would not have to incur these expenses (and I would not now recommend any one to embark in the industry who did not have these necessaries at command), yet these estimates have been criticised because silk-raisers have been unable to realize, in 1885, the profits which I considered attainable in 1879. For, though sharing the opinion of those directly connected with the silk trade, I then believed that the prices of raw silk and cocoons had reached as low a figure as they ever would, the belief proved subsequently unfounded, for fresh cocoons which in Europe sold in 1879 for 47 cents could be purchased, in 1885, for 35 cents per pound. Again, any estimates must needs be approximate only, as they will vary with the race.

This great alteration in the value of silk products has necessarily impaired the accuracy of the estimates given by me in the first edition of this pamphlet. I have therefore prepared another series of figures which are more nearly accurate to-day than the former ones, and are based on the French yellow race.

PROFITS OF PRODUCING COCOONS: ESTIMATES FOR TWO ADULTS, OR MAN AND WIFE.

Average number of eggs per standard ounce of 25 grams, in ordinary yellow races, 37,500.

Number of fresh cocoons per pound, 300 to 400.

Average reduction in weight for choked cocoons, 66 per cent.

Maximum amount of fresh cocoons from 1 ounce of eggs, 93 to 125 pounds.

Allowing for deaths in rearing—26 per cent. being a large estimate—we thus get as the product of an ounce of eggs 69 to 92 pounds of fresh, or 23 to 31 pounds of choked, cocoons.

Two adults can take charge of the issue of from 1 to 3, say 2, ounces of eggs, which will produce 138 to 184 pounds of fresh, or 46 to 62 pounds of choked cocoons.

Price per pound of fresh cocoons (1885), 35 cents (300 cocoons per pound).

184 pounds of fresh cocoons, at 35 cents, $64.40.

Price per pound of fresh cocoons (1885), 25 cents (400 cocoons per pound).

138 pounds of fresh cocoons, at 25 cents, $34.50.

Price per pound of choked cocoons (1885), 80 cents to $1.15.

Value of above products, choked, $36.80 to $71.30.

APPROXIMATE COST OF REELING.

Estimated product of 6 non-automatic steam reels for the 300 working days of the year—1,200 pounds of reeled silk, and 300 pounds of waste silk.

Cost of production of 1,200 pounds of reeled silk, based on the Government experiments at New Orleans, in 1885:

Value of plant:		
Six reels	$500.00	
One steam engine	600.00	
Shafting and miscellaneous	400.00	
	1,500.00	
Interest and depreciation on plant, 20 per cent. per annum		$300.00
Raw material:		
5,076 pounds of choked cocoons, at $1		5,076.00
Labor (as shown at New Orleans), $1.12½ per pound of silk		1,350.00
Fuel, oil, etc		150.00
Total		6,876.00

Value of the above product:

1,200 pounds reeled silk, at $5.50	$6,600.00
300 pounds waste silk, at $1	300.00
Total	6,900.00

In studying these estimates the reader must, as I have said, bear in mind that the silk industry, like all industries, will have its ups and downs—its periods of buoyancy and depression. For the past few years it has been going through one of the latter. But late last fall an upward tendency was shown in prices for raw silk, which, if they remain firm, can not but influence for the better the value of cocoons.

In the preface to the second edition I mentioned the advantages to be gained by raising Silk-worm eggs, though I called attention to the fact that the market for them was in its nature limited and transient, and that European merchants were again producing their own seed by the aid of the improved Pasteur system of selection. Notwithstanding the facts there stated as to the limited nature of the egg market, silk-raisers have been disappointed, after having produced large quantities of eggs, in not finding a ready sale for them. But though the egg market is important in its place, it will readily be seen that it can be, when in a healthy state, no more extensive than is necessary to supply each season the wants of silk growers. In 1884, in France, about 2½ per cent. of the total crop was employed in the production of eggs. These figures, from a country where silk culture is established, furnish a foundation upon which to estimate. Every pound of cocoons which is sold at the filature puts money into the pockets of the silk-raising class; while every pound used in the production of eggs in excess of the amount actually required robs it of the money that it would otherwise receive. The only way to build up the industry, then, is, as I have so often insisted, to create, by the establishment of filatures, a durable and profitable market for cocoons. The production of eggs is simply an incident of comparatively little importance.

I have shown in said preface that silk-raising on an extensive scale is fraught with so many dangers that it is inadvisable to invest capital in such an enterprise. This is partly due to the fact that a large crop must necessarily be raised with the aid of hired labor, and a consequent investment of cash capital. A large rearing requires a large and (for success) a specially constructed building, which must necessarily lie idle for the greater part of the year. It has been found, too, that the average production of cocoons, per ounce of eggs, is much less for large than for smaller crops. Thus one ounce of eggs of good race will produce one hundred pounds of fresh cocoons; while for every additional ounce the percentage is reduced if the worms are all raised together, until for twenty ounces the average may not exceed 25 pounds of cocoons per ounce. Such is the general experience throughout France, according to Guérin-Méneville, and it shows the importance of keeping the worm in small broods, or of rearing on a moderate scale. As a re-

sult we see the great magnaneries disappearing from France and Italy, where in some establishments as many as 60 ounces were at one time annually raised. We find this statement confirmed by looking at the French official statistics for 1884, where it is stated that the cocoons produced in France during that year were raised by over one hundred and forty thousand families, who utilized therefor about two hundred and eighty thousand ounces of eggs, or an average of about two ounces per family.

To beginners I would repeat the advice so often given from this Office, to hatch the first season but a small quantity of eggs; not more than an eighth of an ounce. Experience counts in this as in other industries, and it will be found that, where only a small quantity of worms are being fed, there will be much more time to study their habits and wants. With a year's experience there will be a better chance of profit the second year.

It will not be safe for individuals to rely on reeling their own silk. The art of reeling in modern filatures and with steam appliances has been brought to such perfection that none but skilled reelers can hope to produce a first-class article. Skill comes only after full apprenticeship and practice. The only way in which silk-reeling can be managed profitably at present is where a colony of silk-raisers combine to put up and operate a common filature. Though there is a ready market in the United States for large lots of good silk, it will not be found so easy to dispose of small lots of poorer quality.

Two years ago Congress appropriated $15,000 for the encouragement of silk-culture, and the appropriation was repeated for the present fiscal year. The appropriation was general in its nature, and the method of encouragement left with the Commissioner of Agriculture. In my Annual Reports for 1884 and 1885 details are given as to the work done by the Department under this appropriation, and various questions discussed and conclusions reached as to the outcome of the two years' experience. These need not be repeated here.

Owing to the conviction that the establishment of filatures and their successful operation was the *sine qua non* in putting the industry on a firm basis, a large portion of the money thus appropriated has been devoted to experiments in silk reeling. These experiments have shown that the quality of cocoons produced by American silk-raisers is not yet such as to enable this country to compete with others in the production of raw silk. The quality of a cocoon is most conclusively shown by the quantity of silk which may be unwound from it. A good average result, after the experience of European filatures, is the production of a pound of raw silk from 3.80 pounds of dry cocoons. The Government experiments at New Orleans showed a production of but 1 pound of silk from 4.23 pounds of dry cocoons. The cost of producing silk from a poorer quality of cocoons is proportionately much greater than where the cocoons are of better quality, and the difference is much greater than

would be thought possible by one unacquainted with the industry. We have, therefore, much to accomplish from this point of view before we can hope to make the industry a profitable one in the United States. The cocoons which have been received at the Government stations during the past year have been, to a large extent, raised by persons who were inexperienced, and who were thus unable to produce a first-class cocoon. There is an inclination among these very persons to blame the industry if they do not receive, the first season, what they consider an adequate compensation for the time which they have expended upon the work. And yet these same individuals would not expect to be successful in any other enterprise until they had made themselves thoroughly acquainted, by practical experience, with the special work involved. It is not, therefore, surprising that with such a quality of raw material it has been impossible to produce silk without financial loss. Such a loss, in fact, as shown in my annual report as entomologist, for 1885, was incurred as the result of the experiments. We, however, performed these experiments with non-automatic machinery, and that even of an unimproved type. The loss was, however, so small that we have reason to believe that it can be more than counterbalanced by the use of improved plant. Automatic silk-reels are now being placed upon the market, which not only effect a slight saving in the quantity of raw material employed, but also a very large saving in labor, the cost of which in this country is the principal cause of our inability to compete with Europe and Asia. These new reels are also capable of producing, with comparatively unskilled labor, as good a grade of silk as can be made by the expert workwomen of France.

It will be seen by the estimates given above that silk-culture is not (and it never has been) an exceedingly profitable business, but it adds vast wealth to the nations engaged in it, for the simple reason that it can be pursued by the humblest and poorest, and requires so little outlay. The question of its establishment in the United States is, as I have elsewhere said, "a question of adding to our own productive resources. There are hundreds of thousands of families in the United States to-day who would be most willing to add a few dollars to their annual income by giving light and easy employment for a few months each year to the more aged, to the young, and especially to the women of the family, who may have no other means of profitably employing their time.

"This holds especially true of the people of the Southern States, most of which are pre-eminently adapted to silk-culture. The girls of the farm, who devote a little time each year to the raising of cocoons, may not earn as much as their brothers in the field, but they may earn something, and that something represents an increase of income, because it provides labor to those members of society who at present too often have none that is remunerative. Further, the raising of a few pounds of cocoons each year does not and need not materially interfere with the household and other duties that now engage their time, and it

is by each household raising a few pounds of cocoons that silk-culture must, in the end, be carried on in this as it has always been in other countries."

The reader is reminded that the few quotations not otherwise credited are from the author's Fourth Report on the Insects of Missouri (1871). A number of foreign (more particularly French) terms are unavoidable in treating of silk-culture, as they have no actual equivalents in our language. These and the few technical terms used in the manual are made clear in the glossary.

Finally, I take pleasure in acknowledging the assistance given me in the preparation of this new edition by Mr. Philip Walker, who has acted as the chief agent of the division in the sericultural work during the past two years.

C. V. R.

WASHINGTON, D. C., *May*, 1886.

CHAPTER I.

PHYSIOLOGY AND LIFE-HISTORY OF THE SILK-WORM.

The Silk-worm proper, or that which supplies the ordinary silk of commerce, is the larva of a small moth known to scientific men as *Sericaria mori*. It is often popularly characterized as the Mulberry Silk-worm. Its place among insects is with the *Lepidoptera*, or scaly-winged insects, family *Bombycidæ*, or spinners. There are several closely allied species, which spin silk of different qualities, none of which, however, unite strength and fineness in the same admirable proportions as does that of the mulberry species. The latter has, moreover, acquired many useful peculiarities during the long centuries of cultivation it has undergone. It has in fact become a true domesticated animal. The quality which man has endeavored to select in breeding this insect is, of course, that of silk producing, and hence we find that, when we compare it with its wild relations, the cocoon is vastly disproportionate to the size of the worm which makes it or the moth that issues from it. Other peculiarities have incidentally appeared, and the great number of varieties or races of the Silk-worm almost equals those of the domestic dog. The white color of the species, its seeming want of all desire to escape as long as it is kept supplied with leaves, and the loss of the power of flight on the part of the moth, are all undoubtedly results of domestication. From these facts, and particularly from that of the great variation within specific limits to which the insect is subject, it will be evident to all that the following remarks upon the nature of the Silk-worm must necessarily be very general in their character.

The Silk-worm exists in four states—egg, larva, chrysalis, and adult or imago—which we will briefly describe.

DIFFERENT STATES OR STAGES OF THE SILK-WORM.

THE EGG.—The egg of the Silk-worm moth is called by silk-raisers the "seed." It is nearly round, slightly flattened, and in size resembles a turnip seed. Its color when first deposited is yellow, and this color it retains if unimpregnated. If impregnated, however, it soon acquires a gray, slate, lilac, violet, or even dark green hue, according to variety or breed. It also becomes indented. When diseased it assumes a still darker and dull tint.

Near one end a small spot may be observed. This is the *micropyle*, and is the opening through which the fecundating liquid is injected

just before the egg is deposited by the female. After fecundation and before deposition the egg of some varieties is covered with a gummy varnish which closes the micropyle and serves to stick the egg to the object upon which it is laid. Other varieties, however, among which may be mentioned the Adrianople whites and the yellows from Nouka, in the Caucasus, have not this natural gum. As the hatching point approaches the egg becomes lighter in color, which is due to the fact that its fluid contents become concentrated, as it were, into the central forming worm, leaving an intervening space between it and the shell, which is semi-transparent. Just before hatching, the worm within becoming more active, a slight clicking sound is frequently heard, which sound is, however, common to the eggs of many other insects. The shell becomes quite white after the worm has made its exit by gnawing a hole through it, which it does at the micropyle. Each female produces on an average from three to four hundred eggs. In the standard ounce of 25 grams* there are about 50,000 eggs of the small Japanese races, 37,500 of the ordinary yellow annual varieties, and from 30,000 to 35,000 in the races with large cocoons. The specific gravity of the eggs is slightly greater than water, Haberlandt having placed it at 1.08.

It has been noticed that the color of the albuminous fluid of the egg corresponds to that of the cocoon, so that when the fluid is white the cocoon produced is also white, and when yellow the cocoon again corresponds.

THE LARVA OR WORM.—The worm goes through from three to four

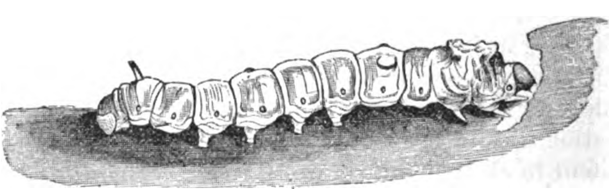

FIG. 1.—Full grown larva or worm (after Riley).

molts or sicknesses, the latter being the normal number. The periods between these different molts are called "ages," there being five of these ages, the first extending from the time of hatching to the end of the first molt, and the last from the end of the fourth molt to the transformation of the insect into a chrysalis.

The time between each of these molts is usually divided as follows: The first period occupies from five to six days, the second but four or five, the third about five, the fourth from five to six, and the fifth from eight to ten. These periods are not exact, but simply proportionate. The time from the hatching to the spinning of the cocoons may, and does, vary all the way from twenty-five to forty days, depending upon the race of the worm, the quality of food, mode of feeding, temperature,

*28½ grams = 1 ounce avoirdupois.

etc.; but the same relative proportion of time between molts usually holds true.

The color of the newly-hatched worm is black or dark gray, and it is covered with long, stiff hairs, which, upon close examination, will be found to spring from pale colored tubercles. Different shades of dark gray will, however, be found among worms hatching from the same batch of eggs. After the first molt, and as the worm increases in size, these hairs and tubercles become less noticeable, and the worm gradually gets lighter and lighter, until, in the last stage, it is of a cream-white color. When full grown it presents the appearance of Fig. 1. It never becomes entirely smooth, however, as there are short hairs along the sides, and very minute ones, not noticeable with the unaided eye, all over the body.

The preparation for each molt requires from two to three days of fasting and rest, during which time the worm attaches itself firmly by the abdominal prolegs (the 8 non-articulated legs under the 6th, 7th, 8th, and 9th segments of the body, called prolegs in contradistinction to the 6 articulated true legs under the 1st, 2d, and 3d segments), and holds up the forepart of the body, and sometimes the tail. In front of the first joint a dark, triangular spot is at this time noticeable, indicating the growth of the new head; and when the term of "sickness" is over, the worm casts its old integument, rests a short time to recover strength, and then, freshened, supple, and hungry, goes to work feeding voraciously to compensate for lost time. This so-called "sickness" which preceded the molt was, in its turn, preceded by a most voracious appetite, which served to stretch the skin. In the operation of molting the new head is first disengaged from the old skin, which is then gradually worked back from segment to segment until entirely cast off. If the worm is feeble or has met with any misfortune, the shriveled skin may remain on the end of the body, being held by the anal horn; in which case the individual usually perishes in the course of time. It has been usually estimated that the worm in its growth consumes its own weight of leaves every day it feeds; but this is only an approximation. Yet it is certain that during the last few days before commencing to spin it consumes more than during the whole of its previous worm existence. It is a curious fact, first noted by Quatrefages, that the color of the abdominal prolegs at this time corresponds with the color of the silk which will form the cocoons.

Having attained full growth, the worm is ready to spin up. It shrinks somewhat in size, voids most of the excrement remaining in the alimentary canal; acquires a clear, translucent, often pinkish or amber-colored hue; becomes restless, ceases to feed, and throws out silken threads. The silk is elaborated in a fluid condition in two long, slender, convoluted vessels, one upon each side of the alimentary canal. As these vessels approach the head they become less convoluted and more slender, and finally unite within the spinneret, from which the silk issues in

a glutinous state and apparently in a single thread. The glutinous liquid which combines the two, and which hardens immediately on exposure to the air, may, however, be softened in warm water. The worm usually consumes from three to five days in the construction of the cocoon and then passes in three days more, by a final molt, into the chrysalis state.

THE COCOON.—The cocoon (Figs. 2 and 3) consists of an outer lining

FIG. 2.—Constricted cocoon, with fine texture (original).

FIG. 3.—Non-constricted cocoon, with coarse texture (original).

of loose silk known as "floss," which is used for carding, and is spun by the worm in first getting its bearings. The amount of this loose silk varies in different breeds. The inner cocoon is tough, strong, and compact, composed of a firm, continuous thread, which is, however, not wound in concentric circles, as might be supposed, but irregularly, in short figure-of-8 loops, first in one place and then in another, so that, in reeling, several yards of silk may be taken off without the cocoon turning around. In form the cocoon is usually oval, and in color yellowish, but in both these features it varies greatly, being either pure silvery-white, cream, or carneous, green, or even roseate.

THE CHRYSALIS.—The chrysalis is a brown, oval body, considerably less in size than the full-grown worm. In the external integument may be traced folds corresponding with the abdominal rings, the wings folded over the breast, the antennæ, and the eyes of the inclosed insect—the future moth. At the posterior end of the chrysalis, pushed closely up to the wall of the cocoon, is the last larval skin, compressed into a dry wad of wrinkled integument. The chrysalis state continues for from two to three weeks, when the skin bursts and the moth emerges.

THE MOTH.—With no jaws, and confined within the narrow space of the cocoon, the moth finds some difficulty in escaping. For this purpose it is provided, in two glands near the obsolete mouth, with a strongly alkaline liquid secretion, with which it moistens the end of the

cocoon and dissolves the hard, gummy lining. Then, by a forward and backward motion, the prisoner, with crimped and damp wings, gradually forces its way out; and the exit once effected, the wings soon expand and dry. The silken threads are simply pushed aside, but enough of them get broken in the process to render the cocoons from which the moths escape comparatively useless for reeling.

FIG. 4.—Silk-worm moth, male (after Riley).

The moth is of a cream color, with more or less distinct brownish markings across the wings, as in Fig. 4. The males have broader antennæ or feelers than the females, and may be, by this feature, at once distinguished. Neither sex flies, but the male is more active than the female, and may be easily recognized by a constant fluttering motion of the wings, as well as the feature mentioned above. They couple soon after issuing, remaining coupled during several hours, and in a short time after separation the female begins depositing her eggs, whether they have been impregnated or not. Very rarely the unimpregnated eggs have been observed to develop.

VARIETIES OR RACES.

As before stated, domestication has had the effect of producing numerous varieties of the Silk-worm, every different climate into which it has been carried having produced either some changes in the quality of the silk, or the shape or color of the cocoons, or else altered the habits of the worm.

Some varieties produce but one brood in a year; such are known as *Annuals*. Others, known as *Bivoltins*, hatch twice in the course of the year; the first time, as with the Annuals, in the early spring, and the second, eight or ten days after the eggs are laid by the first brood. With Bivoltins the eggs of the second brood only are kept for the next year's crop, as those of the first brood always either hatch or die soon after being laid. The *Trevoltins* produce three annual generations. There are also *Quadrivoltins*, and in Bengal a variety known as *Dacey*, which is said to produce eight generations in the course of a year. Some varieties molt but three times instead of four, especially in warm countries and with Trevoltins. Experiments, taking into consideration the size of the cocoon, quality of silk, time occupied, hardiness, quantity of leaves required, etc., have proved the Annuals to be more profitable than any of the Polyvoltins. The principle difficulties encountered in raising other than the annual races arise from the excessive heat of midsummer, which causes disease, and the deteriorated quality of the leaves as explained in Chapter X. Silk-growers are therefore earnestly advised to attempt but one brood per annum ex-

cept where, as in some parts of the Pacific coast, the summers are prolonged and equable.

Commercially cocoons are classed as yellow, white, and green, but through the intermingling of races these colors have become merged one into the other, and it is often difficult to define the line of demarkation. The same trouble exists in classifying varieties by the different countries or provinces from which they have originally come. Prior to the Silk-worm plague of twenty years ago in Europe there was a certain degree of exactness in the lines drawn between such races. Then, however, the indigenous races were to a large extent blotted out, and the egg merchants went first to Turkey, then to Asia Minor and Syria, and finally to China and Japan, in search of eggs that should be free from "the malady." Thus it was that there were brought into France and Italy a large number of races foreign to those countries. These were crossed together, and after the researches of Pasteur had made the resuscitation of the native races possible, they were crossed with these as well. Thus the identity of the old varieties was, in many cases, lost, or they obtained different names.

CHAPTER II.

WINTERING AND HATCHING THE EGGS.

As has been said in the last chapter, the egg of the Silk-worm changes color soon after oviposition. During this operation the contents undergo a chemical change, absorbing oxygen and giving off carbonic acid. This absorption of oxygen is very active during the first six days, after which it rapidly declines and continues at a very low rate during the months which precede hatching. The eggs should, therefore, be wintered in such manner that they have plenty of air; otherwise their development will be seriously interfered with. They must not be packed in thick layers, but should be spread out thinly. For these reasons the eggs at this Department are kept through the winter in boxes of perforated tin, the bottoms of which have a surface of 6½ square inches, each box containing not more than one quarter of an ounce of eggs.

The atmosphere in which the eggs are kept should neither be too dry nor too humid. M. Beauvais found a saturation of 50 per cent. to be the most suitable condition of the air, as when it is below that point the liquids of the eggs evaporate so rapidly as to require a highly saturated atmosphere for their incubation. Excessive moisture, on the other hand, will assist the formation of mold, which will quickly injure the contents of the egg. The eggs should be frequently inspected, and whenever such mold is discovered it should be quickly brushed off and the eggs removed to a drier locality.

Under natural conditions the egg undergoes a partial development as soon as laid, as shown by its changing color. After oviposition, and until subjected to cold, the eggs of the annual races are not capable of hatching out. This is the rule, although we often find in a batch of annual eggs a few accidental bivoltins that hatch some fifteen days after they are laid. The number, however, is very slight, and it has been determined that the temperature to which they are submitted in no way alters the result. During this period, which we call prehibernal, the eggs may be kept at any ordinary temperature, however warm, but once they are submitted to the cold of winter a certain change takes place in them, the nature of which has not yet been determined, and their subsequent warming may then result in hatching. As in our climate warm days are quite frequent in late winter, it is very necessary that the eggs be kept below the hatching temperature until the foliage on which the worms are to feed is developing and all danger from late frosts is at an end. The period of hibernation may be lengthened by keeping the eggs in a cool, dry cellar, with a northerly exposure, and in general this will

suffice. But in such a case the temperature is more or less variable, and the embryo may be started in its development only to be checked by renewed cold. When kept at a uniform low temperature, after having once been cooled, development is imperceptible, and when afterward exposed to the proper hatching conditions, the resultant worms will prove more vigorous. If possible the temperature should never be allowed to rise above 40° F., but may be allowed to sink below freezing point without injury.

When small lots of eggs are to be wintered, they may be placed in ordinary boxes in the cellar, care being taken to observe the precautions noted above as to ventilation, humidity, and temperature. They should also be protected from rats, mice, ants, and other vermin. But where great quantities are to be stored, it will be well worth while to construct special hibernating boxes, where the requisite conditions may be regulated with nicety and precision.

A great object should be to have them hatch uniformly, and this is best attained by keeping together those laid at one and the same time, and by wintering them, as already recommended, in cellars or hibernating boxes that are cool enough to prevent any embryonic development. They should then, as soon as the leaves of their food-plant have commenced to put forth,* be placed in trays and brought into a well-aired room where the temperature averages about 75° F. If they have been wintered adhering to the cloth on which they were laid, all that it is necessary to do is to spread this same cloth over the bottom of the tray. If, on the contrary, they have been wintered in the loose condition, they must be uniformly sifted or spread over sheets of cloth or paper. The temperature should be kept uniform, and a small stove in the hatching-room will prove very valuable in providing this uniformity. The heat of the room may be increased about 2° each day, and if the eggs have been well kept back during the winter, they will begin to hatch under such treatment on the fifth or sixth day. By no means must the eggs be exposed to the sun's rays, which would kill them in a very short time. As the time of hatching approaches, the eggs grow lighter in color, and then, if the weather be dry, the atmosphere must be kept moist artificially by sprinkling the floor or otherwise, in order to enable the worms to eat through the egg-shell more easily. They also appear fresher and more vigorous with due amount of moisture.

It will be found that eggs which have been subjected to great cold during the winter will require a longer time in their incubation than those which have been kept at a higher temperature, and it is also true, as has been intimated above, that when the atmosphere in which the eggs have been retained has been excessively dry it will require con-

*Too much stress can not be laid on the importance of beginning the rearing of worms as early as possible, so that the excessive heat of summer may be avoided. Beginners are very apt to delay sending for eggs until after the leaves have put out, and there is not only more danger of the hatching of the eggs in transit, but the worms will be maturing during very warm weather.

siderable humidity to cause them to hatch. Such matters must be largely regulated by the experience of the individual raiser.

The desired conditions can be better regulated in specially constructed incubators than in an open room. A simple form of incubator is shown in Fig. 5. It consists of a tin cylinder with a perforated shelf and a

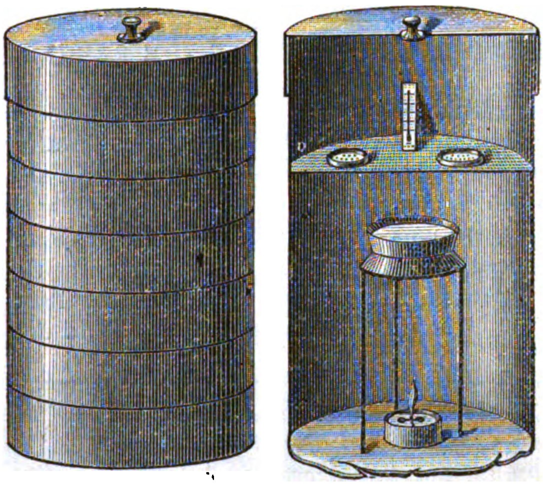

FIG. 5.—Incubator made of tin-ware (after Roman).

movable cover. Under the shelf is placed upon a tripod a small vessel of water, beneath which burns a small night-lamp. This apparatus may be made about eight times the size of the drawing. A similar and simple form of basket-ware incubator is shown in Fig. 6. This possesses

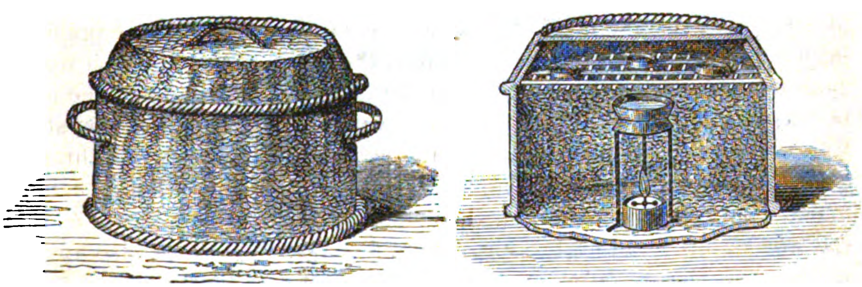

FIG. 6.—Incubator made of basket-ware (after Roman).

the advantage of being permeable to the air and of thus insuring a more complete ventilation for the eggs. Many modifications of these designs will suggest themselves to individuals; amongst others the surrounding of the cylinder of the incubator first described with a jacket, in which hot water may be placed, by means of which the temperature of the interior may be regulated with a considerable degree of nicety.

CHAPTER III.

IMPLEMENTS THAT FACILITATE THE RAISING OF SILK.

The room in which the rearing is to be done should be so arranged that it can be thoroughly and easily ventilated and warmed if desirable. A northeast exposure is the best, and buildings erected for the express purpose should combine these requisites. If but few worms are to be reared, all the operations can be performed in trays upon tables, but in large establishments the room should be arranged with deep and numerous shelves, ranging one above the other from floor to ceiling, as shown in Fig. 7. The width of these shelves should not exceed 5 feet,

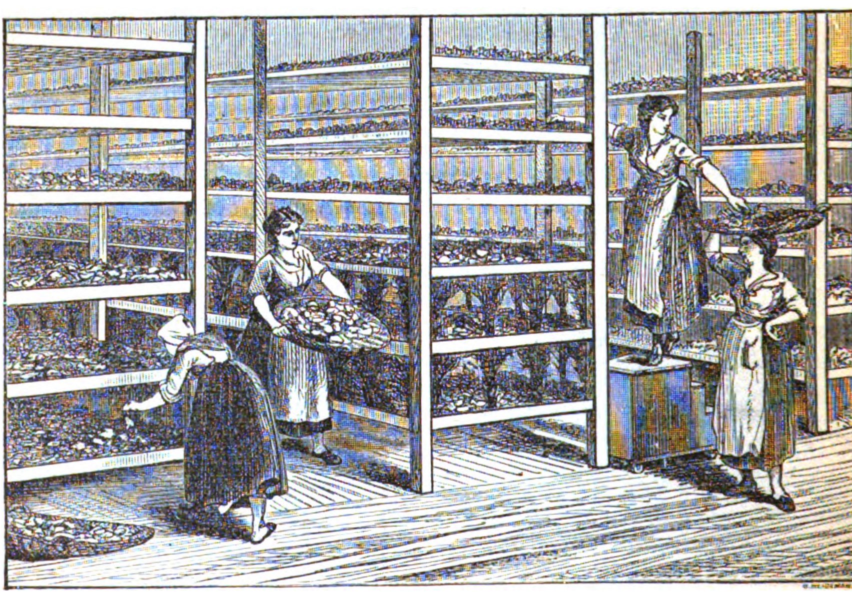

FIG. 7.—A modern magnanerie (after Gobin).

as those in charge must be able to reach from either side to the middle of each table. Bearing this in mind, the dimensions of these tables may be made to suit the room in which the worms are reared. The vertical distance between two shelves should not be less than 20 inches, but if this space is greatly increased it will be found inconvenient to obtain brush of sufficient length to form the arches upon which the cocoons are to be spun.

The form in which the tables are constructed is also immaterial, and should depend upon the resources of the owner. Where canes are abundant, as upon the Mississippi bottom, such a shelf as is shown in

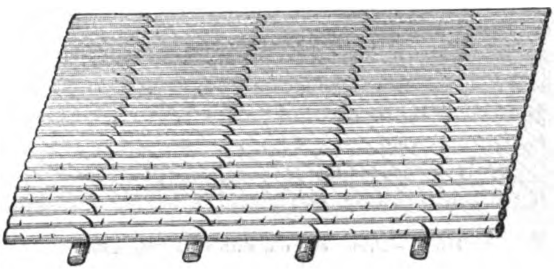

FIG. 8.—Shelf made of canes (after Roman).

Fig. 8 will be found inexpensive and satisfactory. To construct a shelf in this manner, say 5 by 8 feet, there should be selected for cross-pieces four stout canes about one inch through at the small end and 5 feet 4 inches long. Having procured a quantity of smaller canes, 8 feet long, lay out the four cross-pieces some eighteen inches apart, and, placing a cane across them, lash the whole together with stout cord. This is done by having an end of cord attached to each cross-piece, which, after it is carried over the smaller cane, is brought around the cross-piece and fastened by a slip knot, as will be better understood by reference to

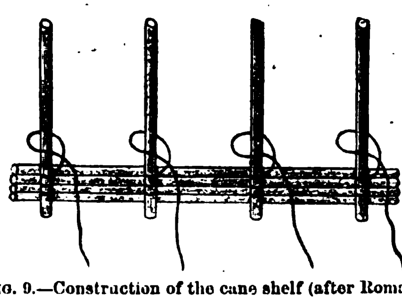

FIG. 9.—Construction of the cane shelf (after Roman).

Fig. 9. The second cane should be placed tip to butt with the first, and so on alternately. Fig. 10 shows a shelf formed with wire-work, which

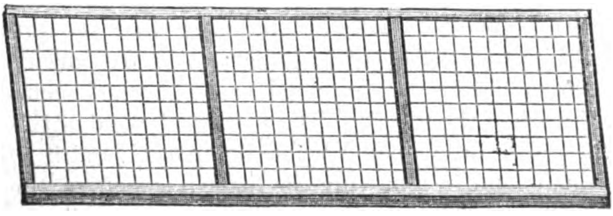

FIG 10. Wire-work shelf (after Roman).

makes a strong and light article. The form shown in Fig. 11 is essentially the same, being covered with wooden slats. Placing these diagonally increases the stiffness and diminishes liability to break.

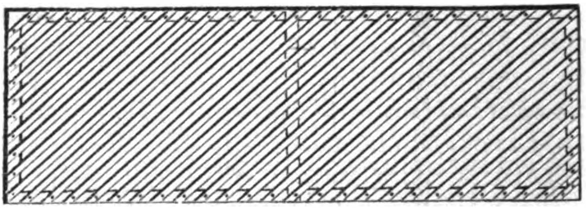

FIG. 11.—Frame covered with slats (original).

Where it is desired to have a neat and convenient standard, upon which a small quantity of worms may be reared, it may be constructed after the manner of that shown in Fig. 12, the shelves being made as

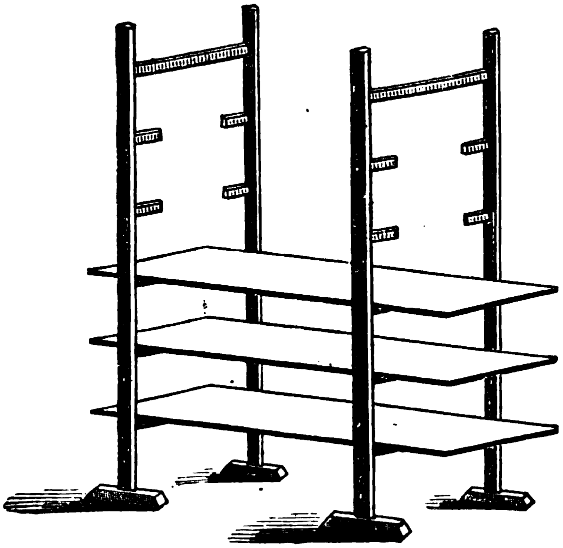

FIG. 12.—Standard for holding shelves (original).

shown in either of Figs. 10 or 11. The principal requisites in the construction of all the above articles are lightness and strength, and the shelves should be so constructed as to permit the free circulation of the air. All wood should be well seasoned, as green wood seems to be injurious to the health of the worms. The shelves above described must be covered with strong brown paper before being used, and it will be found to be more convenient in removing the litter if sheets of the same size as the table are employed.

In rearing Silk-worms great care should be observed in not handling them more than is absolutely necessary, and as, in clearing up the litter made by the larvæ, it is necessary to transport them from one table to another, several schemes have been adopted to accomplish this object. The first transfer made upon the birth of the worms is usually performed with the aid of ordinary mosquito netting, which is lightly laid over the hatching eggs. Upon this can be evenly spread freshly-plucked leaves or buds. The worms will rise through the meshes of the net, and cluster upon the leaves, when the whole net can be easily removed.

This netting has the disadvantage of sagging in the middle and lumping the worms. Netting of a coarser mesh may be used later in rearing, but it should be stretched on light frames. This method of transfer is such a great convenience and time-saver that in France, for many years, paper, stamped by machinery with holes of different sizes, suited to the different ages of the worms, has been used. The material employed is a stout manila paper, and the perforations vary in size, as shown in Fig. 13. I have experienced some difficulty in the

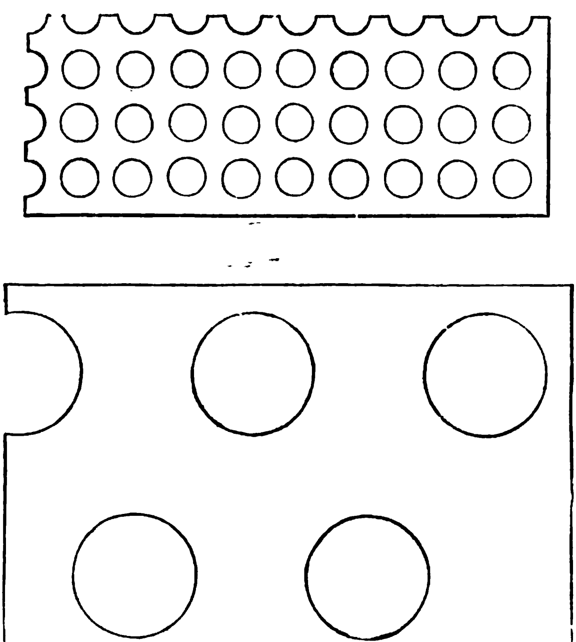

FIG. 13.—Perforated paper, showing the sizes of the perforations in the first and last ages (original)

use of this paper during the fifth age, the worms being so large that when the holes are partially obstructed by twigs or leaf-stems they must force themselves through the restricted space, often cutting themselves on the sharp edges of the paper. This may be avoided by the

use, during that age, of a lattice-work tray, such as is shown in Fig. 14.

To prevent this tray from pressing upon the worms beneath, it should be propped up by small blocks placed under the corners.

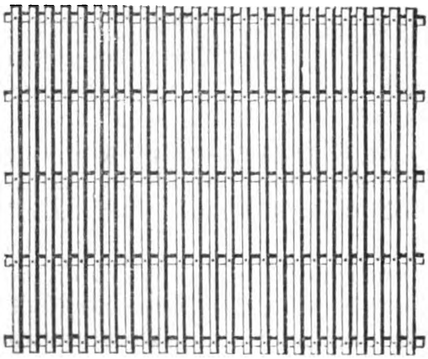

FIG. 14.—Lattice-work transfer tray (original).

When large pieces of perforated paper are used they should be handled by two persons. By cutting them into smaller pieces and using a transfer tray (Fig. 15) one person can perform the necessary work with ease. Such a tray is most conveniently made about 13 by 19 inches inside. When the paper, which should be made about one inch smaller each way, has been covered with leaves, and the worms have come through the perforations in search of their food, the whole may easily be slipped into the transfer tray, and as easily taken from it in depositing the worms on another table.

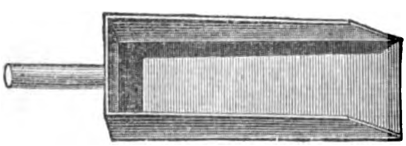

FIG. 15.—Transfer drawer (after Roman).

In gathering leaves for the worms it will be found convenient to employ a bag (Fig. 16), so arranged that it may be attached around the waist like an apron. Two such sacks may be made from an ordinary meal bag.

The worms should be made to spin their cocoons on brush so arranged as to form arches between the shelves, as is shown in Fig. 19.

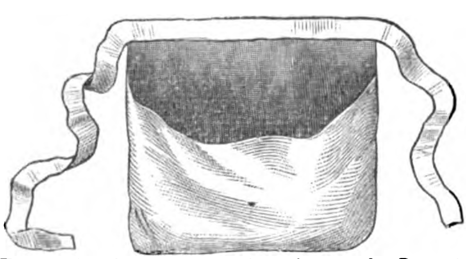

FIG. 16.—Bag for gathering mulberry leaves (after Roman).

For the same object the cocooning ladder shown in Fig. 17 was devised in 1842 by M. Davril. It consists of two central supports, across each side of which (Fig. 18) are nailed small strips of about one-quarter by one-half inch section, 1½ inches apart. The strips on one side are placed opposite the spaces between the strips on the other side. The ladder may be made about 30 by 15 inches, and the central supports about five-eighths inch thick. When in use the ladder is placed slantingly between the tables, with the central supports horizontal.

A thermometer is a very useful adjunct to the appliances above described.

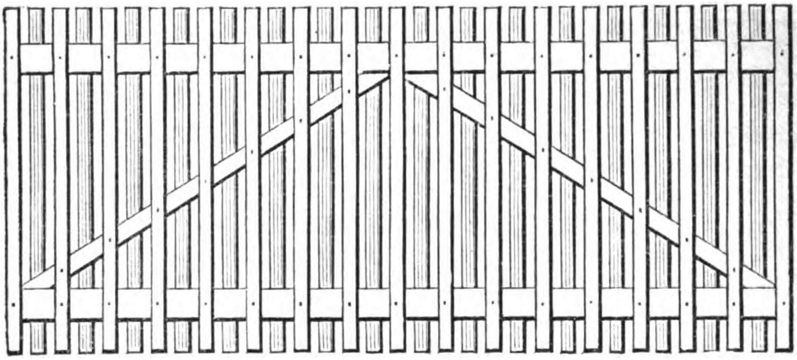

FIG. 17.—The Davril cocooning ladder.

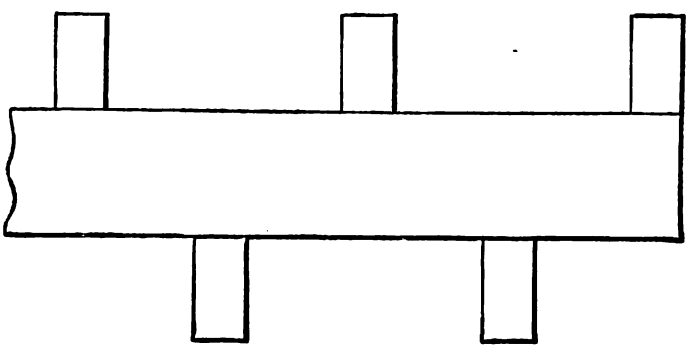

FIG. 18.—Partial end view of the Davril cocooning ladder (full size).

CHAPTER IV.

THE REARING OF SILK-WORMS.

The chief conditions of success in silk raising are (1) the use of good eggs; (2) proper care of the worms.

The means of obtaining pure eggs will be described in the next chapter, and we will here consider the second of the conditions.

Unless new, and especially where the worms raised with them the preceding season have suffered from any disease, all the implements and furniture used should be cleansed and purified by carefully scrubbing in soap and water. The walls of the room may, where convenient, be submitted to the same operation, and covered with a strong coat of whitewash. The room should then be tightly closed and thoroughly fumigated with burning brimstone during an entire day and night. It may then, after being well aired, be used for the rearing of Silk-worms.

The eggs when about to hatch, whether brought to this condition by the systematic processes described in Chapter II, or by ruder methods, should be spread out on clean paper in as thin layers as possible. Over them should be lightly laid small pieces of ordinary mosquito-netting. When the worms begin to appear there should be sparsely scattered over this netting a few buds or finely-cut leaves. The newly born larvæ will at once pass through its meshes in search of food, and the whole can then be easily removed to the table upon which they are to pass their first age.

It is recommended by many to feed the worms while in this age, and, consequently, weak and tender, leaves that have been cut up or hashed, in order to give them more edges to eat upon and to make less work for them. This, however, is hardly necessary with annuals, although it is quite generally practised in France. With the second brood of Bivoltins it might be advisable, inasmuch as the leaves at the season of the year when they appear have attained their full growth and are a little tough for the newly-hatched individuals. In the spring, however, the leaves are small and tender, and nature has provided the young worms with sufficiently strong jaws to cut them.

Many rules have been laid down as to regularity of feeding, and much stress has been put upon it by some writers, most advising four meals a day at regular intervals, while a given number of meals between molts has also been urged; but such definite rules are of but little avail, as so much depends upon circumstances and conditions. The food should,

in fact, be renewed whenever the leaves have been devoured, or whenever they have become in the least dry, which, of course, takes place much quicker when young and tender than when mature. This also is an objection to the use of the hashed leaves, as, of course, they dry very quickly. The worms eat most freely early in the morning and late at night, and it would be well to renew the leaves abundantly between 5 and 6 a. m., and between 10 and 11 p. m. Additional meals should be given during the day, according as the worms may seem to need them. It is only by experience that one can learn just what amount of food should be given to the worms. It may prove dangerous to feed them too copiously, as in the first ages the worms may become buried and lost in the litter, while later the massing of food in an attempt to satisfy their ravenous appetites may cause it to ferment and become productive of disease.

Great care should be taken to pick the leaves for the early morning meal the evening before, as when picked and fed with the dew upon them they are more apt to induce disease. Indeed, the rule should be laid down, never to feed wet or damp leaves to your worms. In case the leaves are picked during a rain they should be thoroughly dried before being fed; and on the approach of a storm it is always well to lay in a stock, which should be kept from heating by occasional stirring. Care should also be taken to spread the leaves evenly, so that all may feed alike. During this first and most delicate age the worm requires much care and watching.

As the fifth or sixth day approaches, signs of the first molt begin to be noticed. The worm begins to lose appetite, grows more shiny, and soon the dark spot already described appears above the head. The larva at this time generally wanders to an unencumbered spot where it may shed its skin in quiet and often gets hidden and buried under the superimposed leaves. When the first worms show these signs of molting, food should be given more sparingly and the meals should cease altogether as soon as the most forward worms awaken. When the time for the molt is near, say during the fourth day, it will be well to clear away the litter so that the worms may pass the crisis on a clean bed.

Some will undoubtedly undergo the shedding of the skin much more easily and quickly than others, but no food should be given to these forward individuals until nearly all have completed the molt. This serves to keep the batch together, and the first ones will wait one or even two days without injury from want of food. It is, however, unnecessary to wait for all, as there will always be some few which remain sick after the great majority have cast their skins. These should either be set aside and kept separate, or destroyed, as they are usually the most feeble and most inclined to disease; otherwise the batch will grow more and more irregular in their moltings and the diseased worms will contaminate the healthy ones. It is really doubtful whether the silk raised from these weak individuals will pay for the trouble of rearing

them separately, and it will be better perhaps to destroy them. The importance of keeping each batch together, and of causing the worms to molt simultaneously, can not be too much insisted upon as a means of saving time.

As soon as the great majority have molted they should be copiously fed, and, as they grow very rapidly after each molt, and as they must always be allowed plenty of room, it will probably become necessary to divide the batch, and this is readily done at any meal by removing the net or tray when about half of the worms have risen and replacing it by an additional one. The space allotted to each batch should, of course, be increased proportionately with the growth of the worms. The same precautions should be observed in the three succeeding molts as in this first one.

The second and third castings of the skin take place with but little more difficulty than the first, but the fourth is more laborious, and the worms not only take more time in undergoing it, but more often perish in the act. At this molt it is perhaps better to give the more forward individuals a light feed as soon as they have completed the change, inasmuch as it is the last molt and but little is to be gained by the retardation, whereas it is important to feed them all that they will eat, since much of the nutriment given during the last age goes to the elaboration of the silk.

It would, too, be found inconvenient if all the worms were to arrive at the spinning period together, as extra assistance would be required to place the brush on which they spin their cocoons.

At each successive molt the color of the worm has been gradually whitening, until now it is of a decided cream color. Some breeds, however, remain dark, and occasionally there is an individual with zebra-like markings.

As regards the temperature of the rearing-room, great care should be taken to avoid all sudden changes from warm to cold, or *vice versa*. A mean temperature of 75° or 80° F. will usually bring the worms to the spinning-point in the course of 35 days after hatching, but the rapidity of development depends upon a variety of other causes, such as quality of leaf, race of worm, etc. If it can be prevented the temperature should not be permitted to rise very much above 80°, and it is for this reason that a room with a northern or northeastern exposure was recommended as preferable to any other. The air should be kept pure all of the time, and arrangements should be made to secure a good circulation. Great care should be taken to guard against the incursions of ants and other predaceous insects, which would make sad havoc among the worms were they allowed an entrance, and all through the existence of the insect, from the egg to the moth, rats and mice are on the watch for a chance to get at them, and are to be feared almost as much as any other enemy the Silk-worm has.

So much depends upon the conditions of development mentioned

above that it is impossible to state the exact quantity of food consumed by the Silk-worm during its life. It will not be far from the truth, however, to place the amount consumed by the issue of an ounce of healthy eggs, which matures in 35 days, at 6½ pounds during the first age, 20 pounds during the second, 65 pounds during the third, 200 pounds during the fourth, and during the fifth and last age 1,250 pounds. This makes a total of between 1,500 and 1,600 pounds. It need hardly be said that the food mentioned must be of the best quality. Were it poor, it would be impossible to give any figures at all.

Too much can not be said in favor of giving the larvæ plenty of room. Every worm should be free to move easily without incommoding its fellows. We should therefore allow the issue of an ounce of eggs during the first age, from 10 square feet at the beginning to 30 square feet at the end of the age, daily extending the space occupied by them by spreading their food over a greater table surface. In the second age, they should spread in the same manner so as to cover from 50 to 75 square feet, in the third from 100 to 160 square feet, and in the fourth from 200 to 320 square feet. Entering the last age, spread over 430 square feet of surface, they should gradually be extended until they occupy, at the spinning period, 640 square feet. It need hardly be said that when the worms have been decimated by disease the surface occupied by them need not be so extensive.

The litter of the worms should be cleared away by the use of netting or perforated paper, before and after each molt, and once at about the middle of the third age. While small, the frass, dung, and detritus dry rapidly, and may (though they should not) be left for several days in a tray with impunity; but he who allows his trays to go uncleaned for more than a day during the two last ages will suffer in the disease and mortality of his worms just as they are reaching the spinning point.

Summed up, the requisites to successful Silk-worm raising are: 1st. Uniformity of age in the individuals of the same tray, so as to insure their molting simultaneously. 2d. No intermission in the supply of fresh food, except during the molting periods. 3d. Plenty of room, so that the worms may not too closely crowd each other. 4th. Fresh air and as uniform temperature as possible. 5th. Cleanliness. The last three are particularly necessary during the fourth and fifth ages.

PREPARATIONS FOR SPINNING.

With eight or ten days of busy feeding, after the last molt, the worms, as we have learned before, will begin to lose appetite, shrink in size, become restless, and throw out silk, and the arches for the spinning of the cocoons must now be prepared. These can be made of twigs of different trees, two or three feet long, set up upon the shelves over the

worms, and made to interlock in the form of an arch above them. Interlace these twigs with broom-corn, hemlock, or other well-dried

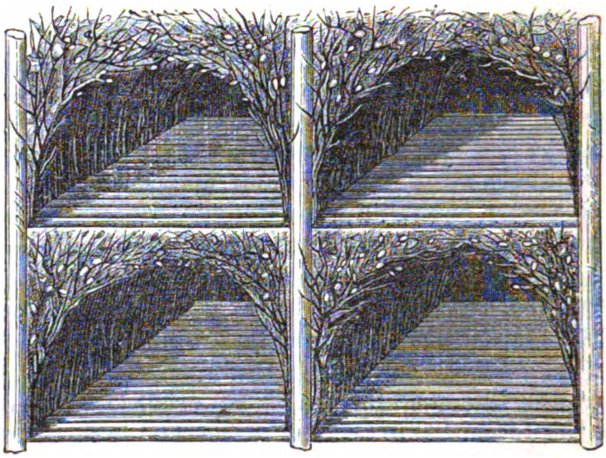

FIG. 19.—Method of constructing arches upon which the cocoons are spun (after Roman).

brush. The feet of each arch should be only about a foot apart. The Davril cocooning ladder, described in Chapter III, may be used with advantage in the place of the brush arches.

The temperature of the room should now be kept above 80°, as the silk does not flow so freely in a cool atmosphere. The worms will immediately mount into the branches and commence to spin their cocoons. They will not all, however, mount at the same time, and those which are more tardy should be fed often, but in small quantities at a time, in order to economize the leaves, as almost every moment some few will quit and mount. There will always be a few which altogether fail to mount, and prefer to spin in their trays. It is best, therefore, after the bulk have mounted, to remove the trays and lay brush carefully over them. The fact that the worms already mounted make a final discharge of soft and semi-fluid excrement before beginning to spin makes this separation necessary, as otherwise the cocoons of the lower ones would be badly soiled.

As the worms begin to spin they should be carefully watched, to guard against two or three of them making what is called a double or treble cocoon, which would be unfit for reeling purposes. Whenever one worm is about to spin up too near another, it should be carefully removed to another part of the arch. In two or three days the spinning will have been completed, and in six or seven the chrysalis will be formed.

GATHERING THE COCOONS.

Eight days from the time the spinning commenced, it will be time to gather the cocoons. The arches should be carefully taken apart, and the spotted or stained cocoons first removed and laid aside. Care should

be taken not to stain the clean ones with the black fluids of such worms as may have died and become putrid, for there are always a few of these in every cocoonery. The outer cocoons of loose or floss silk are then removed from the inner cocoons or pods, and the latter sorted according to color, weight, and firmness of texture; those which best resist pressure indicating that the worm has best accomplished its work. Too much care can not be taken to remove the soft or imperfect cocoons, as, if mixed with the firm ones, they would be crushed and soil the others with their contents. The very best of the firm cocoons are now to be chosen as provision for eggs for the next year, unless the raiser prefers buying his eggs to the trouble of caring for the moths and keeping the eggs through the winter. Eggs bought from large establishments are, however, apt to be untrustworthy, and it is well for all silk-raisers to provide their own seed. The precautions to be taken in choosing cocoons for reproduction are set forth in Chapter VI.

Kept at a temperature of about 70° F., new silk cocoons lose, through the giving off of humidity by the chrysalides, a material proportion of their weight. According to Dandolo the loss in 100 pounds during the first ten days amounts to about 7½ per cent.* The amount of humidity in the atmosphere naturally affects this result. The loss continues until the cocoons are thoroughly dry, when it will be found that they have lost two-thirds of their original weight.

* Dandolo states that 100 pounds of cocoons will suffer the losses indicated by the following table:

	Pounds.
Weight when taken from the brush and after the floss has been removed	100.0
Weight one day after	99.1
Weight two days after	98.2
Weight three days after	97.5
Weight four days after	97.0
Weight five days after	96.6
Weight six days after	96.0
Weight seven days after	95.2
Weight eight days after	94.3
Weight nine days after	93.4
Weight ten days after	92.5

CHAPTER V.

ENEMIES AND DISEASES OF THE SILK-WORM.

As regards the enemies of the Silk-worm but little need be said. It has been generally supposed that no true parasite will attack it, but in China and Japan great numbers of the worms are killed by a disease known as "uji." This is produced by a Tachinid called by Rondani *Ujimyia sericaria*, and the life history of which has been carefully worked up by Prof. C. Sasaki of Japan (Journal Science College, Imp. Un., Tokio, Japan, 1886, Vol. I, part I).

There are, however, several forms of disease against which it is necessary to guard and of which it is therefore necessary that silk-raisers should have an intimate knowledge. Through the multitude of local names given to these diseases abroad, one would suppose that there were as many diseases to which the Silk-worm is subject. But Pasteur, after studying the subject very carefully, concluded that all may be considered as varieties of four principal diseases, viz: the *muscardine*, *pébrine*, *flacherie*, and *grasserie*.*

The *gattine*, one of these varieties, is considered by Pasteur as a mild form of the pébrine,† but Maillot, in a later work,‡ considers it as a species of the flacherie.

These diseases are found to some extent intercurrent, though at all times one (at least one of the first three) has been more prevalent than the others, generally amounting to a plague. So in 1849 we find M. Guérin-Méneville studying, on the part of the French Academy, the then prevalent disease, the muscardine. This was soon followed, in the fifties, by a veritable scourge in which the pébrine was the leading feature, with flaccidity (*flacherie*) quite frequently found. The same learned body appointed Pasteur to study the causes of these diseases, and after two years of patient research he devised a means, which will hereafter be described, of successfully preventing the return of the pébrine. This made way for flaccidity, which is to-day the dread of silk-raisers, for although it does not reach the importance of a plague, its effects are distinctly visible upon the national crops of cocoons in France and Italy, and I have never known it to be absent from worms reared by me almost every year for nearly two decades in this country. The grasserie has never attained any such importance, but occurs in rare instances only.

* Pasteur, "*Études sur la maladie des vers à soie*," Vol. I, p. 225.

† Pasteur, "*Études*," etc., Vol. I, p. 12.

‡ Maillot, "*Leçons sur le vers à soie du murier*," p. 109.

MUSCARDINE.

The first of these, the *muscardine*, has been more or less destructive in Europe for many years. It is of precisely the same nature as the fungus (*Empusa muscæ*), which so frequently kills the common house-fly, and which sheds a halo of spores, readily seen upon the window-pane, around its victim.

A worm about to die of this disease becomes languid, and the pulsations of the dorsal vessel or heart become insensible. It suddenly dies, and in a few hours becomes stiff, rigid, and discolored; and finally in about a day, a white powder or efflorescence manifests itself, and soon entirely covers the body, developing most rapidly in a warm, humid atmosphere. No outward signs indicate the first stage of the disease, and though it attacks worms of all ages, it is by far the most fatal in the fifth or last age or stage, just before the transformation.

"This disease was proved by Bassi to be due to the development of a fungus (*Botrytis bassiana*) in the body of the worm. It is certainly infectious, the spores, when they come in contact with the body of the worm, germinating and sending forth filaments which penetrate the skin, and, upon reaching the internal parts, give off minute floating corpuscles which eventually spore in the efflorescent manner described. Yet, most silk-worm raisers, including such good authorities as F. E. Guérin-Méneville and Eugène Robert,* who at first implicitly believed in the fungus origin of this disease, now consider that the Botrytis is only the ultimate symptom—the termination of it. At the same time they freely admit that the disease may be contracted by the Botrytis spores coming in contact with worms predisposed by unfavorable conditions to their influence. Such a view implies the contradictory belief that the disease may or may not be the result of the fungus, and those who consider the fungus as the soie cause certainly have the advantage of consistency. Dr. W. B. Carpenter, an eminent microscopist, believes in the fungus origin of the disease, and thinks it entirely caused by floating spores being carried in at the spiracles or breathing orifices of the worm, and germinating in the interior of the body.

Whichever view be held, it appears very clear that no remedies are known, but that care in procuring good eggs, care in rearing the worms, good leaves, pure, even-temperatured atmosphere, and cleanliness are checks to the disease.

As the sole means of disseminating the disease are the spores which only appear several hours after the death of the worm, the most rational means of preventing the spread of muscardine is by carefully taking from the tables all dead worms as soon as they are discovered, and if the disease seems to have gained a foothold in the magnanerie it will be well to remove the litter oftener and give the worms more

*Guide à l'éleveur de vers à soie.

space. The spores retain their power of communicating disease for at least three years; hence the importance of cleansing and fumigating as described in the last chapter.

PÉBRINE.

External symptoms.—"The disease, pébrine, shows itself outwardly by the dwindling away of the worms and their inequality of size; eating little, they do not grow as large as when in their normal state. At the end of a few days black spots frequently make their appearance on the skin, resembling punctures or burns; the anal horn, the prolegs, the soft parts between the rings, are especially subject to these spots."*

FIG. 20.—Silk-worms spotted with pébrine, twice natural size (after Pasteur).

Fig. 20 "represents, at twice the natural size, the anterior part of the body of sick worms covered with such spots. In one of the worms, *a*, they are just becoming visible, and the eye should be aided by a magnifying glass to render them distinct; the other, *b*, shows them farther advanced, easily recognizable with the naked eye, if the worm be examined with a little attention. Finally, Fig. 21 shows one ring spotted with pébrine, magnified to six diameters. For this cut was chosen a worm bearing two kinds of marks, one with clear-cut edges, the others surrounded with a halo. The first are wounds, the others the true spots belonging to the disease and serving as an indication of its existence, if not always, at least under many circumstances. The halos in question have generally a yellowish tint. They must be observed through a magnifying glass to be well seen."†

FIG. 21.—Joint of a Silk-worm showing wounds and spots of pébrine, six times natural size (after Pasteur).

These spots disappear with the shedding of the skin at each molt only to reappear again within a few days. Worms bearing them are figured in plate I, A, B, C, and D. In addition to these symptoms it is noticed that the prolegs do not seem to attach themselves easily to objects. In the chrysalis the abdomen is very much swollen and the rings stretched. In a highly-diseased moth the wings are wrinkled as when they emerge

* Maillot, *Leçons*, etc., p. 96.

† Pasteur, *Études*, etc., p. 15.

from the cocoon, and are often covered with bloody pimples, which become black on drying. Part of the body and the wings have a leaden color; but this must not be confounded with a certain natural brownness which some healthy moths exhibit, and which extends over the whole body; but it is only with highly diseased subjects that these exterior signs become visible, and to find the symptoms of the disease we are often obliged to resort to a microscopical examination of the interior of the insect.

Internal symptoms.—"In the interior of the body microscopic observation reveals the presence of innumerable corpuscles of an ovoid shape (Plate II), filling the cells of the walls of the stomach, those of the silk glands, the muscles, the fatty tissues, the skin, the nerves—in a word, all the portions of the body. There are often so many of them that the cells of the silk glands become swollen and white, and appear to the naked eye to be sprinkled over with chalky spots; the silky liquid always remains exempt from this parasite, but it is much less abundant than when the worm is in a healthy state."*

In 1849, M. Guérin-Méneville first noticed these floating corpuscles in the bodies of the diseased worms. They were supposed by him to be endowed with independent life; but their motion was afterwards shown by Filippi to depend on what is known as the Brownian motion, and they are now included in the class *Sporozoa* of the *Protozoa*, and referred by Balbiani to the order *Microsporidiæ*.

These corpuscles are found in the Silk-worm in all its stages—in the egg, larva, chrysalis, and moth. It was for a long time a mooted question as to whether they were the true cause or the mere result of the disease; but the praiseworthy researches of Pasteur have demonstrated that pébrine is entirely dependent upon the presence and multiplication of these corpuscles. The disease is both contagious and infectious, because the corpuscles which have been passed with the excrement or with other secretions of diseased worms may be taken into the alimentary canal of healthy ones when they devour leaves soiled by them, and because it may be inoculated by wounds inflicted by the claws of other worms. The malady may be carried to a distance with the corpusculous dust coming from infected magnaneries, and such dust holds the power of communicating disease from one season to another.

When the "seed" is thus diseased it hatches irregularly and incompletely, and the larvæ often perish before or during the first molt. When the corpuscles are taken into the intestines, as above described, the malady usually becomes apparent, through some of the external symptoms mentioned, at the end of four or five days. M. Pasteur determined that if the worm partook of the soiled food after the fourth molt it would make its cocoon, but that corpuscles would be found in profusion in the chrysalis and moth. If, on the other hand, the worm is thus ex-

* Maillot, *Leçons*, etc., pp. 96, 97.

posed to contagion just before spinning, the chrysalis will show the parasites only during its last days, while they will be abundant in the moth.

From the mother moth the corpuscles pass into the egg and give rise to the diseased "seed" already remarked upon. Disease in the male will not, however, affect its progeny. The egg is formed while the insect is still in the chrysalis state, and it has been ascertained that where the corpuscles become abundant only during the last days of this stage they enter into the seed to a very small degree only, if at all. For this reason eggs are sometimes found to be entirely pure, though the issue of a highly pébrinous parent. The development and multiplication of these corpuscles, though ordinarily very rapid, is insignificant in the egg until the formation of the larva begins. It will be easily understood that, though the parasite may exist in the vitellus of the egg, its detection may be extremely difficult. But when the development of the embryo has commenced, the number of corpuscles grows also, so that just before, or, better still, just after the time of hatching they may be found by hundreds upon a casual observation. Upon a microscopical examination at this time, Vittadini, in 1859, founded his system of selection, examining samples of eggs just at the time of hatching and rejecting those lots which showed the corpuscular disease.

At that epoch it was believed that the corpuscles existed even in the healthy moth when well advanced towards its natural death. But Pasteur showed this theory to be fallacious, proving, as we have said above, that the corpuscle is only present when the moth is diseased. He showed that, where the moth is free from the parasite, the egg, too, would be exempt, and that, as a rule, where the corpuscles exist in the moth, then its issue will probably be corpusculous also. There is, to be sure, even then a chance of its purity, as mentioned above—that is, where the corpuscles become abundant in the chrysalis only after the formation of the egg. But here, too, it is highly probable that the malady will have so affected the general health of the parent as to make her issue more apt to succumb to disease, as in the case of flaccidity. Therefore it is laid down as a rule, and upon this rule the Pasteur system of selection rests, that if, upon microscopical examination of the mother moth, the corpuscles of pébrine are found, then her eggs and issue will also be pébrinous, and should be destroyed.

The details of the Pasteur system of selection will be given in the next chapter.

FLACCIDITY (*flacherie*).

External symptoms.—When, after the worms have passed their fourth molt, and are eating well and regularly, they have all the appearance of perfect health and vigor, and the silk-raiser feels full confidence in the success of his crop, some will often be seen to crawl to the edges of the trays, and lie there languid and without motion. But for the loss of their wonted activity and the cessation of their naturally vora-

cious appetite, one would still think the worms in perfect health, for they yet retain all the outward perfection of form that we have remarked above (Plate I, Fig. G). In color they have, perhaps, become somewhat more rosy, especially if the disease is in a violent form. On touching them, however, we find them soft, and even in this seemingly live condition they are often dead. Had the worms been carefully observed at this time, it would have been seen that the beating of the dorsal vessel was gradually becoming slower, and that it finally stopped altogether. A green drop appears at the mouth and the worm secretes a dirty liquid, which soils the anal orifice and gradually closes it.

Before many hours are passed the skin begins to shrivel and draw in around the fourth and fifth joints of the body, viz: those two lying between the set bearing the legs proper and the set bearing the prolegs (Plate I, Fig. F). Later, at this restricted point, the body begins to turn brown (Plate I, Fig. E), then black, and the whole worm is soon in an advanced state of putrefaction. Then, and even before the death of the worm, a sour odor is perceptible in the magnanerie, due to the fatty volatile acids exuded by the victims to the disease. Should the malady strike the insects at a later period, when they are ready to spin their cocoons, the same languishing air will be observed; they will show a reluctance to crawl up into the arches, and will be seen to gather around their bases, seeking some place which it requires no exertion to attain to spin their cocoons. Many of those which reach the branches stretch themselves out motionless on the twigs and die there. They are to be seen later hanging by their prolegs in different states of putrefaction (Fig. 22). When these symptoms are observed we may be sure that the worms are attacked by flaccidity (*flacherie*).

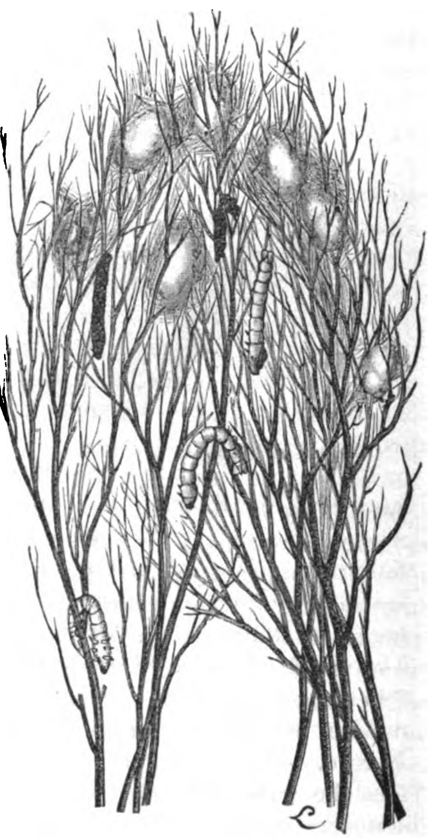

FIG. 22.—Silk-worms at the spinning period, after death by flaccidity (after Pasteur).

Internal symptoms.—A microscopic examination of the intestines of the sick worm will show masses of undigested food, and the coats of the intestines will be found to be opaque. Here, too, the microscope re-

veals the parasites ordinarily attending putrefaction, chief among which is a bacillus, seen sometimes with and sometimes without a bright nucleus. There also exists a special form of ferment, not unlike that which accompanies the formation of vinegar (*Mycoderma aceti* Pasteur), which is found in short chains, the links of which are almost spherical

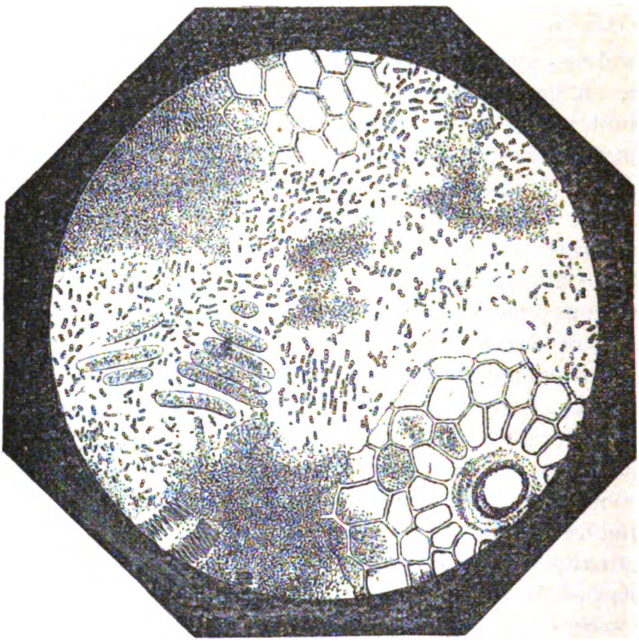

FIG. 23.—Chain ferment, taken from the stomach of a flaccid chrysalis. Magnified 400 times (after Pasteur).

in form (Fig. 23).* These two parasites are sometimes found together and sometimes separately. When the bacillus is abundant death quickly follows its appearance, and the disease, spreading rapidly, will sometimes destroy a whole school in a single day. At times this bacillus appears so short a time before the spinning of the cocoon that the worms are able to mount into the branches, and even make their cocoons and become chrysalides. Then, however, the disease overcomes them, and their putrefaction produces foul cocoons. This case is, however, more rare, and in general the bacillus is not often found in the chrysalis. When the ferment alone appears the disease progresses differently. The worms then show the same languor on the approach of the spinning period, and the same indisposition to make their cocoons; but even then they mount the branches, perform their work of spinning, are transformed into chrysalides, and these into moths which may have a fine appearance. The silk crop may even be exceptionally good; but where this state has existed, when the worm has been without its usual

* The distance from center to center of the links of these chains is about 1 μ (=0.001^{mm}=0.00004 inch).

agility at the spinning time, where it has shown this apparent laziness, then, though the cocoons be of the firmest and the moths the finest, there will exist a weakness, a constitutional debility, that will show itself in the next generation. This is the only way in which flaccidity is hereditary, in this predisposition of the worm to succumb to disease on account of the affection which weakened but which did not kill the parent.

Such are the symptoms attending flaccidity in Silk-worms, and from them M. Pasteur evolved the theory that the disease was caused by the fermentation of the food in the intestinal tube of the larva, which was followed by diarrhea and the closing of the anal orifice, as already mentioned. Confirming this theory of food fermentation is the fact that the same parasite (Fig. 23) which is found in the intestines of flaccid larvæ also exists in a fermented broth of mulberry leaves. Digestion thus arrested, the worm ceases to eat and becomes languid. The gases evolved by the processes described burst the walls of the intestines and cause the death of the victim. Such is the Pasteur theory, followed, as a rule, by the French scientists.

Italians, on the contrary, believe with Verson and Vlacovich, who claim to have observed "that in the flaccid worm the micro-organisms are not at times to be found; that it has been proved that in the beginning there occurs a tumefaction of the membrane of the intestines, and that this membrane, as the disease advances, disappears here and there, and finally altogether. According to them flaccidity consists primarily of a lesion of the membranous walls of the intestines, which would generally be followed by the development and multiplication of the micro-organisms which Pasteur considered the primitive cause of the disease. It is a fact, nevertheless, that all acknowledge, that in most cases flaccidity is accompanied by bacilli and ferments in great numbers in the intestinal tube."*

Flaccidity generally appears after some sudden change in the weather or temperature, as, for instance, a thunder shower, or a hot, heavy day. It is apt, too, to follow the feeding of wet or fermented food. If the shelves go too long without cleaning and begin to mildew; if the worms are too crowded on the table and their natural respiration interfered with, flaccid subjects will soon appear in the school. These, by their unhealthy excrement, soil the food of their neighbors, who quickly follow them in the path of disease. It is thus that flaccidity becomes highly infectious.

No very satisfactory means have been proposed for combating this malady when once it appears. It would be well, on the discovery of the first victims, to take the worms remaining healthy into another apartment and give them more space and plenty of air. Attentive care may then save the crop, though by no means with certainty.

* Perroncito, *I Parassiti*, p. 35.

To avoid the disease one should carefully follow the fundamental rules already laid down (Chapter IV), though even then circumstances may be against the silk-raiser and the crop be lost through no apparent fault of his.

GRASSERIE.

This disease is of little importance, and has therefore received but little attention from scientists. It is thus described by Maillot:*

"In the middle of a school of worms in good condition it is not rare, as a molt approaches or just before the spinning begins, to find here and there some worms which crawl slowly, and have a shining, stretched, thin skin; the body is of a bright yellow in the yellow, and of a milky white in the white races; a troubled liquid transudes through the skin; soiling the food and the worms over which the diseased subjects pass. * * * A moist, cold, stagnant air seems to favor the occurrence of grasserie. The disease is not contagious, * * * nor does it appear that it can be transmitted by heredity. From this point of view there is nothing to be feared, unless a great number die of the malady, in which case it will be imprudent to use the stock for reproduction."

Victims of this disease should be removed as soon as discovered, as they are apt to crawl into the branches and soil the cocoons spun by other worms.

Prefacing the next chapter we may draw the following conclusions from what has been said: Grasserie is never hereditary, as the victim never dies later than in the chrysalis state, and the disease can never originate in the moth. This is equally true of muscardine, provided the moths be not mingled with worms covered with the spores of the Botrytis. In such a case the moth might also catch the disease and its general debility decrease the vigor of its progeny. Flaccidity is hereditary in an indirect manner, a debility springing from the affection of the parent rendering its issue more apt to succumb to disease. And finally, pébrine is hereditary in its true sense, the corpuscles passing from the mother through the egg to the next generation. In the production of eggs, then, we need look for flaccidity and the pébrine only, the other diseases not entering into the consideration.

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* *Leçons, etc.*, p. 111.

CHAPTER VI.

REPRODUCTION.

It has been said in Chapter IV that the first condition of success in raising Silk-worms is to "procure good eggs." The object of the present chapter is to describe the most approved processes of producing such eggs.

Were it not for the diseases to which the Silk-worm is subject, the old, simple processes of egg production might still be followed, and even now, unless the egg producer is able and ready to undertake the microscopical examination required by the Pasteur system, it is needless to observe the more complex rules for the isolation and examination of the moths.

The simple process formerly employed in all sericultural countries consisted in stringing the cocoons and letting the moths couple, as in the modern process. A sheet was then hung up with the lower edge so turned as to form a trough into which any badly gummed eggs might fall. After uncoupling, the females were placed upon the sheet and permitted to lay their eggs promiscuously. The only precaution taken against disease was in the selection for reproduction of lots of cocoons whose larvæ had shown no signs of any malady, and which were themselves of first quality. From what has been said it will at once be seen that pébrine contracted after the fourth molt and the slow form of flaccidity due to the presence of chain-ferment are not thus guarded against. The modern system has a deeper, more scientific basis, and aims to guard against these.

The Pasteur system of microscopical selection.—As we have seen, pébrine and flaccidity are the only diseases which it is necessary to guard against in selecting eggs. If pébrine or flaccidity have appeared in a positive form in the larvæ, either through the external or internal symptoms described in the last chapter, no further examination need be resorted to, as the stock will evidently be unfit for reproduction. The most important and positive sign of the latter disease to be looked for is languor at the spinning time. If a greater degree of certainty is desired, or if the egg-producer has not had the opportunity of observing the rearing of the worms, a miscroscopical examination of the chrysalis may be resorted to. In flaccidity this examination should be confined to the stomach, where the chain-ferment to be sought for is more easily found. M. Pasteur gives the following directions for extracting this organ:

"Cut away the walls of the thorax of the chrysalis with fine scissors, after the manner shown in Fig. 24, so as to reveal the stomach *s*. Draw this out with a pair of tweezers. The restricted part of the digestive tube, which unites the stomach with the urinal sack *u*, should then be cut. The anterior part of the digestive tube now alone holds the stomach in place, and this easily gives way. Lay the small ball thus withdrawn on a glass slide and scratch away the very soft, fatty envelope which covers the interior. Of this interior substance take a piece as big as the head of a pin, wash it with a drop of distilled water, and, placing it upon a slide with a cover glass over it, examine it with a microscope magnifying about four hundred diameters. With a little experience this work may be done very rapidly. It would be well to take out at the same time the stomachs of, say, twenty chrysalides, and lay them on as many glass slides. * * *

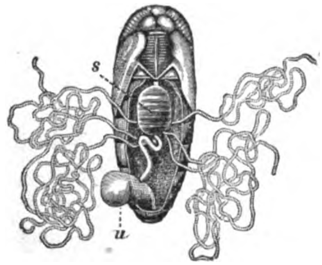

FIG. 24.—Anatomy of the chrysalis, showing method of extracting the stomach (after Pasteur).

"The first few days after the formation of the chrysalis the contents of the stomach are generally very liquid, which makes their extraction inconvenient. It is better to make these observations seven or eight days after the spinning begins, when the matter will be found to have more consistence. * * * Fig. 23, page 38, shows the appearance of the ferment found in flaccid chrysalides under a magnifying power of 400 diameters. It is associated with the débris of leaves, morsels of the trachea, and chlorophyl cells. These matters ordinarily accompany the little ferment in the stomach of the chrysalis, because of the incomplete digestion of the leaf whenever it is submitted to fermentation."*

No parasite indicative of flaccidity has been discovered other than this ferment, which is not found in the adult insect; and if the transformation into the moth is permitted, all opportunity will be lost for detecting the disease.

In pébrine, on the contrary, the corpuscle is found in the moth as well as in the chrysalis. We might, therefore, wait for a final examination of the moth to be made after oviposition. But, in case disease is then found, it will be too late to stifle the cocoons, and the emergence of the moths will have ruined them for certain commercial purposes. For this reason it is important to detect the disease, if it exists, at as early a stage of the work as possible. If the larvæ have shown no external signs of the pébrine, it would be well to microscopically examine a few of the last worms to spin. The corpuscles will be found in these laggards, if anywhere.

Isolation and examination of the moths.—If left to themselves the insects remain in the chrysalis state for from two to three weeks in our ordi-

* Pasteur, *Études*, etc., Vol. I, p. 233.

nary summer weather. Their development may, however, be hastened or retarded by increasing or lowering the temperature. This fact is taken advantage of to obtain a few adult insects which may be microscopically examined before the whole lot becomes fully developed.

I was very much pleased with the method employed by M. Maillot, which I had an opportunity of examining at Montpelier, in 1884, and I here give a description of it in his own words:

"Three or four days before the cocoons are taken from the branches we take, here and there, from the early spinners as well as the late, several hundred cocoons; as, for example, five hundred from a lot of 90 pounds. This sample should be placed in an oven or warm room, where it will be kept day and night at a temperature of from 100° to 110° Fah., and a high degree of humidity. In this way the formation of the moth is hastened. As during this time the cocoons of the lot itself remain at a temperature of from 75° to 90°, and often during the night at even lower temperatures, we shall still have time to stifle them if the lot is discarded, or to string them into chains if, on the contrary, it proves healthy.

"Every two days we take ten chrysalides from the sample and examine them microscopically for corpuscles. If we find them in the first eight or ten days, no matter in how small quantities, we can be sure that the proportion of pebrinous moths will be considerable. When the chrysalides are mature, which is easily seen by their eyes becoming black and the eggs harder to break under the pestle, and also by some of them turning into moths, we proceed to the definite examination. We crush one by one the moths which have come out and the chrysalides which remain and search for corpuscles; the per cent. which is thus found will not differ materially from that which exists in the whole lot."*

The examination of the chrysalides here mentioned may be made in the manner already described when searching for the ferment of flaccidity and at the same time. But if we are looking for the pébrine only we need simply crush the whole chrysalis in the manner hereafter described for the moth.

Proceeding now with stock of which the purity has been ascertained by one or more of the different methods of observation above described, 200 cocoons should be selected for each ounce of eggs that it is desired to produce. In making this selection great care should be exercised in taking only cocoons that are fine in texture and firmly made. This fineness is one of the prerequisites of a first-class cocoon. What is meant by this difference in texture will be seen by an examination of Figs. 2 and 3, page 14, the former being fine and the latter coarse. The firmness of the cocoon, depending as it does on the amount of silk which it contains, is an indication of the vigor of the worm, and another item to be considered in selecting stock for reproduction. Rules have been

*Maillot, *Leçons*, etc., p. 250.

given for the determination of the sex of the inclosed insect, and among them, perhaps the most common, is the assertion that those that are constricted in the middle (Fig. 2) contain males, while those not constricted (Fig. 3) contain females. This, however, may be regarded as an indication rather than a fixed rule, and there are races in which the cocoon is almost uniformly constricted and others where the reverse is true. But this careful selection for sex is comparatively unimportant, and we consider it wiser to choose the cocoons in relation to their firmness and texture, and trust to chance to bring as many male moths as female. Double cocoons, where two worms have spun together, should never be used in egg-making.

The proper cocoons having thus been selected, they should be strung upon stout threads about 3 feet long. Care should be taken not to prick the chrysalides with the needle while passing it through the end of the cocoon in making the chains. These chains should then be hung in a cool, darkened room while waiting for the moths to emerge. They should not be placed near any object which would be soiled by the secretions emitted by the moths on their emergence from their cocoons.

Previous to this emergence there should be prepared for each ounce of eggs to be produced about one hundred small bags of fine muslin (cheese cloth makes a good material), made in the following manner: Cut the cloth in pieces 3 by 6 inches, then fold one end over so as to leave a single edge of about three-quarters of an inch, as shown in Fig.

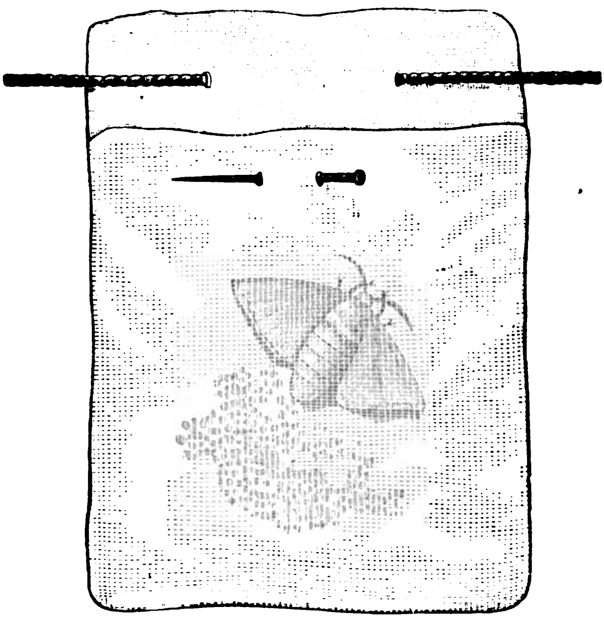

FIG. 25.—Cell used in the Pasteur system of egg-laying (after Roman).

25. This should be sewn up into a bag with the upper end open, and then turned inside out so that the seams will cause the sides to bulge. Thus completed they are called "cells." The cells should be strung

on a cord stretched across the room. Some trouble having been experienced in keeping the moth from crawling out of the cell at either side of the pin, which is the method of closing it shown in the cut, the scheme shown in Fig. 26 was adopted last year in the Department.

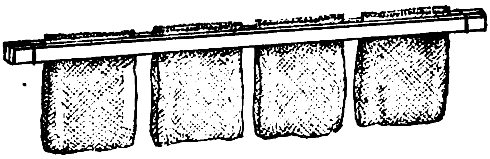

FIG. 26.—Method of clamping cells (original).

This consists in clamping the bags in fours between two sticks of wood, rough sawn, about one-half by one-quarter inch through and 14 inches long. They are bound together by rubber bands and may be laid across parallel wires stretched across the room at about 13 inches apart. M. Pasteur suggests that a simple piece of cloth about four inches square be used instead of the sack. The moth lays her eggs on this and is then retained by being fastened to the cloth, the corner of which is turned up over her and a pin passed through it and over her wings (Fig. 27).

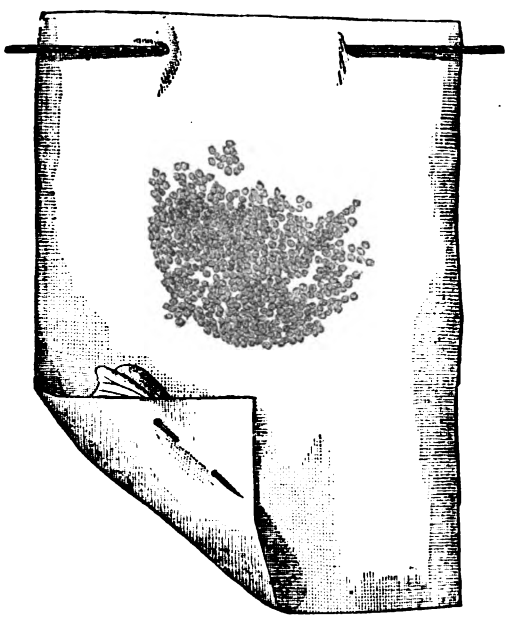

FIG. 27.—Cell used in the Pasteur system of egg-laying (after Pasteur).

Some trouble has been experienced by this process, as the eggs, if not properly gummed to the cloth, will sometimes fall off and be lost, and the moths, not being confined as in the sacks, will wander to other cloths and get their eggs mixed with those of other moths, which would be detrimental to the microscopical selection to be hereafter described. It has the advantage, however, of enabling the microscopist to avoid the labor of turning the sacks.

The moths emerge from the cocoons, as a rule, from 5 to 8 o'clock in the morning. At the latter hour many of them will be found coupled and clinging to the chains. These should be carefully taken by the wings and placed upon a table by themselves, the single moths being placed upon another table where they will couple if the sexes are evenly divided. They should then be transferred to the first table as the fluttering of the male moths is apt to disturb the couples. These should be left together until 4 or 5 o'clock in the afternoon, when they may be separated by drawing them gently apart by the wings. The females should then be placed in the cells or upon the cloths already described, where they will at once commence their egg-laying, completing it in about thirty-six hours. Most of the males may then be thrown away, though it may be wise to keep a few of the more active ones to compensate for any superabundance of females in the issue of the following day. But little difficulty will be encountered in distinguishing the sexes, the males being noticeable by their smaller abdomens, more robust antennæ, and by their greater activity.

When the eggs have been laid, the microscopical examination of the moths should be made with a view to ascertaining whether or no they are afflicted with pébrine. The entire moth should be ground up with a few drops of distilled water* in a small glass mortar (1 ounce is a convenient size). A drop of this water is then taken with a medicine dropper and placed upon a glass slide with a cover glass over it. It is then microscopically examined with a power greater than three hundred diameters. Plate II shows a field very highly charged with the corpuscles of pébrine. When the moths are not examined until some time has elapsed after their death, they will be found to contain other germs peculiar to putrefaction. These do not indicate any disease that would affect the egg or its issue; nor does their presence imply any lack of vigor in the parents. They are simply post-mortem parasites. Great care should be taken in cleansing the mortar, pestle, and other implements before making an examination, by washing them in an abundance of water and rinsing them thoroughly with distilled water. In making the above examination only the corpuscles of pébrine need be looked for. The bacilli and the ferments of flaccidity are rarely found in the moth.

* The amount remaining in the mortar after rinsing is sufficient.

CHAPTER VII.

CHOKING THE CHRYSALIS.

In most silk-producing countries the parties who raise the cocoons sell them to the reeling establishments before suffocation is necessary, as these establishments have better facilities for this work than are to be found in private families. If, however, the reeling is done by the raiser, or some time must elapse before the cocoons can be sent to a reeling establishment, some means must be used to kill the contained chrysalis before the cocoon is injured for reeling purposes by the egress of the moth. This can be done by stifling them with steam or choking them by dry heat. Steaming is the surest, quickest, and best method, if the facilities are at hand; it can be done at any steam mill. The cocoons are laid upon shelves in a tightly-sealed box and the steam is turned in. Twenty minutes will suffice to do the required work, and the cocoons are then dried in the sun.

The following apparatus has been used by Mr. Walker at the Department:

It consists of a tin reservoir, about one-third filled with water. Slightly above the surface of the water is a movable perforated partition, B, intended to prevent spattering during ebullition. The upper portion contains a perforated pan for holding the cocoons, while all is tightly closed by a cover. Cocoons may be thoroughly stifled by exposure in this apparatus, over boiling water, for twenty minutes. It will be seen, too, that much the same apparatus may be contrived by the use of a deep kettle, into which is set an ordinary colander full of cocoons. It is well to avoid, however, so filling the kettle with water that it will splash upon the cocoons in boiling, as they should only be subjected to the action of steam. The apparatus is 12 inches in diameter and 13 inches deep, and will stifle from 3 to 4 pounds of cocoons at a time.

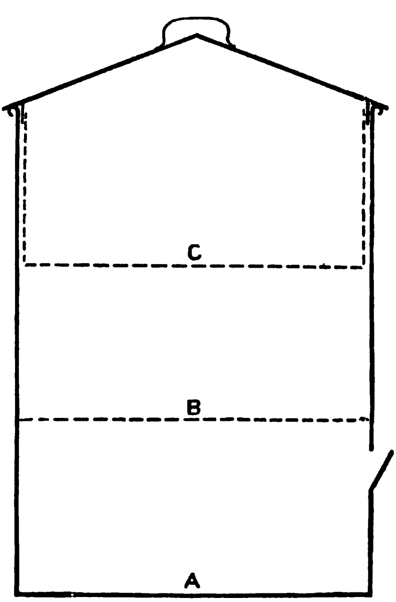

FIG. 28.—Simple stiffling apparatus.

The dry-heat method occupies a much longer time. The cocoons are placed in shallow baskets and slipped on iron drawers into an oven which is kept heated to a temperature of about 200° F. This should not be increased for fear of burning the silk. This operation lasts from two to twenty-four hours. A certain humming noise continues so long as there is any life, and its cessation is an indication that the chrysalides are all dead. Where the choking is well done there is little loss, only about 1 per cent. of the cocoons bursting at the ends. After choking in this manner, the cocoons should be strewn upon long wooden shelves in the shade, with plenty of air, and, for the first few days, frequently stirred. After remaining on these shelves for about two months, with occasional stirring, the chrysalides become quite dry, and the cocoons will preserve indefinitely. They are, however, still subject to the attacks of rats and mice, and the little beetles known as "museum pests," belonging to the genera *Dermestes* and *Anthrenus*, are attracted by the dead chrysalis within and will penetrate the cocoon, injuring it for reeling purposes. In the warm Southern States the dry-heat choking can be accomplished by simple exposure to the sun. Two or three days of such exposure are sufficient. But, as strong wind may annihilate the effect of the sun's warmth, it is good to have for that purpose long boxes, 4 feet wide, sides 6 inches high, to be covered with glass frames. This will increase the heat, and, by absorbing the air of the box, stifle the chrysalis most surely. The glass cover should be slightly raised to permit the escape of the excessive moisture which evaporates from the cocoons, and care should be had to keep out the ants.

CHAPTER VIII.

SILK-REELING.

Spun, reeled, and thrown Silk.—From the cocoon the silk is by different processes transformed into spun or reeled silk. The former is generally made from pierced cocoons or silk waste, and serves in the manufacture of inferior classes of tissues. The method of manufacture consists in cleaning and macerating the raw material, after which it is carded and made into thread somewhat after the manner of cotton. The process of producing reeled silk, which will be hereafter treated at length, consists, in general, of softening the gluten of the cocoons in hot water and then taking the ends of the constituent threads of several of them together and winding these threads from the cocoons upon a reel.

By virtue of the next process of manufacture to which this material is submitted it becomes *thrown silk*. Thrown silk is classified as organzine and tram. It is made either from spun or reeled silk. Tram consists of two or three threads of reeled (or spun) silk twisted together at about 75 to 100 turns per running meter (67.5 to 90 per yard). It is used in making the warp in weaving. Organzine, used in the woof, is produced by twisting two threads together at about 500 to 600 turns per running meter, and then taking two of the threads thus made and twisting them together in the opposite direction at about 400 to 500 turns. It is, in the language of the trade expression, "cable laid."

It is the object of this work to deal only with one of these classes; that is to say, reeled, or, as it is commonly called, raw silk. Although the former name indicates more exactly than the latter the processes to which the raw material has been previously submitted, yet the term "raw silk" has acquired a special meaning by trade usage and applies only to reeled silk.

The process of Silk-reeling.—The cocoons should have been roughly sorted before they were spread out in the cocoonery, the double and feeble specimens having been laid aside. They should now be sorted so that cocoons of the same color and shade may be reeled together, for the use even of cocoons of the same color but of different shades will give a streaked skein of silk. They should, too, be sorted as to their texture. Those of fine texture, among ordinary cocoons, are considered first choice and are used to produce the finest qualities of raw silk. They are more easily unwound than those of coarser texture which are

called satiny cocoons. This satinage appears to be due to the fact that the successive layers of the cocoon are insufficiently gummed together. As a result the water penetrates quickly into its center while it is being reeled and causes it to sink to the bottom of the basin, which interferes with the process of unwinding. Towards the end a satiny cocoon comes off in flocks, making a dirty silk.

A comparison of the cocoons shown in the cuts on page 14 may convey an idea of the difference of texture mentioned, Fig. 2 being fine, and Fig. 3 of coarse grain. In addition to the above features some regard must be paid to the reeling of cocoons of the same size together. An extended experience is needed to make a rapid cocoon-sorter, and it is work that should be followed without intermission, that the knack necessary to quickness may not be lost.

The process of reeling cocoons, while extremely simple, is still one that requires an amount of skill to acquire which the experience of several months is necessary. The cocoons are first plunged into boiling water, whereby their gluten is softened in such a manner as to render the unwinding of the filaments an easy matter. This done, they are brushed with a small broom, to the straws of which their fibers become attached. The bundle of filaments is then taken and they are unwound until each cocoon shows but one clean thread. These three operations are called "cooking," "brushing," and "cleansing." All of these operations can be accomplished mechanically.

The elements of the mechanism of all modern silk-reels are essentially the same. They are shown in Fig. 29, and consist, in general, of a basin,

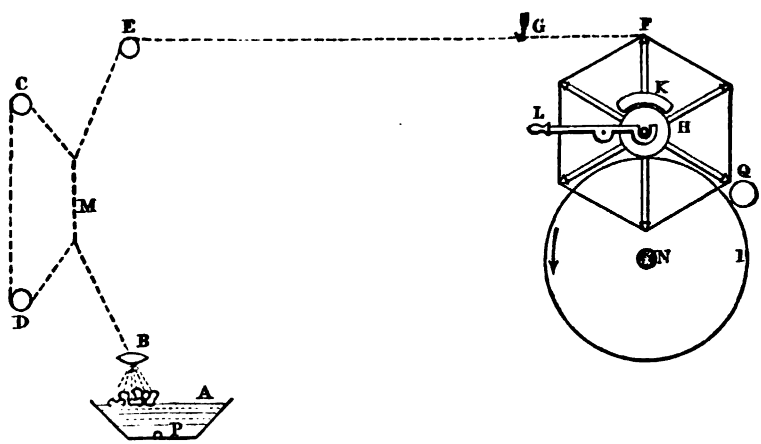

FIG. 29.—Elements of the mechanism of a modern silk reel (original).

A, in which is a perforated steam-pipe, *P*, by means of which the water in the basin may be heated. A few inches above the surface of the water is placed a perforated agate, *B*. The cocoons having undergone the three operations mentioned, the ends of the filaments of four or more

of them are twisted together into a thread, which is passed through the hole in the agate. From this it runs through the "croisure" *M*, which will be hereafter explained, and over the guide *E* to the reel at *F*. Between *E* and *F* the thread passes a guide, *G*, moving to and fro (in a line perpendicular to the plane of the paper), which distributes it in a broad band over the surface of the reel. This facilitates the drying of the silk, without which the gluten would bind together the threads of the skein as it does those of the cocoons, and thus ruin its commercial value. In winter it is often necessary to use supplementary means to effect this drying. Perhaps one of the best is by passing a large steam-pipe near the reel, as at *Q*. The shaft of the reel carries at one end a friction-wheel, *H*, which rests on the large friction-wheel *I* that constantly revolves on the shaft *N*, and thus motion is imparted to the reel. In order to stop the reel it is only necessary to raise the wheel *H* from its bearings by means of the lever *L*. This movement presses the wheel against the brake-shoe *K*, and its motion is at once arrested.

As has been said above, the thread is passed between the agate and the reel through the croisure. The making of the croisure consists in twisting the thread around itself or another thread so as to consolidate its constituent filaments and wring the water from it and thus aid in its drying. The mode of the formation of this croisure forms the principal distinguishing mark between the French and Italian systems of reeling. The former is called the "Chambon system." Each reeler manages two threads. These are passed through separate agates, and after being brought together and twisted twenty or thirty times around each other are again separated and passed through guiding eyes to the reel. The other system, called "tavellette,"* consists in passing the thread up over a small pulley *C*, down over another *D*, and then twisting it around itself, as shown at *M*, in Fig. 29, and thence to the reel.

The cocoon filament is somewhat finer in the floss or beginning, thickens at the point of forming the more compact pod, and then very gradually diminishes in diameter until it becomes so fine as to be incapable of standing the strain of reeling. Therefore a thread which is made up of five new filaments becomes so small when the cocoons from which it is drawn are half unwound as to require an addition. This addition might also be made necessary by the rupture of one of the constituent filaments. It is here that the skill of the operator is called into play. When her experience tells her that the thread needs nourishing from either of these causes she takes the end of the filament of one of the cocoons which lie prepared in her basin, and, giving it a slight snap or whiplash movement with the index finger, causes it to wind around or adhere to the running thread of which it from this moment becomes a constituent part. This lancing, as it is called, of the end of the filament, although in hand reeling performed in the manner described, is also accomplished mechanically, several devices having been invented for this purpose.

*The trade name of the small pulley mentioned.

They consist, in general, of a mechanism which causes a small hook to revolve in a horizontal plane about the running thread, and to twist around it any end of the filament that may be placed in the path of the hook. The reeler, seeing that a new filament is needed, holds the end of one in the way of the attaching device and it is automatically caught.

The temperature of the water used while reeling the cocoons varies from 140° to 175° F. The more cocoons have been cooked the lower will be the temperature required. It is customary, however, to work in the neighborhood of the maximum limit. Whenever the silk rises in locks the temperature of the water is known to be too hot, and when it unwinds with difficulty the temperature is, on the contrary, too low. The operator is supplied with a skimmer with which to remove all chrysalides and refuse silk; also, with a basin of cold water, in which to cool her fingers, which are being constantly dipped in the hot basin.

It is highly important that the silk be kept as clean as possible. It lacks cleanness when the filament ends are badly attached in lancing, when the figure 8 loops, of which the cocoon is composed, come off one or more at a time instead of unwinding continuously, or when the thread after breaking is not neatly knotted. All these faults show in weaving and injure the value of the silk.

According to Dandolo the fresh cocoons consist, by weight, of:

	Per cent.
Chrysalides	84.20
Castings	0.45
Silken pods	15.35

It is from this 15.35 per cent. that the reeler draws her silken thread. But a large proportion of even this is lost, so that there is recovered but 8, 9, or rarely 10 per cent. of the original weight of the cocoons. From this it will be seen that it takes from 10 to 12½ pounds of fresh cocoons, or 3¼ to 4⅛ pounds of dry ones to make a pound of silk. A more usual working average, with good stock, is in the neighborhood of 3¾ pounds of dry cocoons per pound of silk. If cocoons are of poorer quality they necessarily produce less silk and their commercial value falls off in far greater proportion than their power of silk production.

CHAPTER IX.

PHYSICAL PROPERTIES OF REELED SILK.

Certain physical properties are of great importance in determining the commercial value of reeled silk. They are its cleanliness, already mentioned; its mean size; the irregularities in its size; its ductility, or, as it is wrongfully but universally called, its elasticity; its tenacity, and the amount of soluble gum which it contains.

The mean size of a skein is determined in the following manner: One thousand yards of the thread is wound off on a reel, supplied with a counter called an *éprouvette*, and made into a little skein termed an *échevette.* This échevette is then weighed and the number of sixty-fourths of a dram which it is found to equal becomes the size number of the thread. This process is called the sizing, or, colloquially, the "dramming" of silk.

In Europe the same system is employed, but the units are a length of 476 meters (400 old French ells) and a small weight called the *denier.* One dram silk in America is equivalent to a thread of 17⅛ deniers in France.

Until recently there has been no means of determining the irregularities in size existing in a silken thread, but manufacturers were content to approximate it by weighing four échevettes per sample skein. The difficulty in making this determination is owing to the fact that the thread is not round, but flattened, being, in fact, in its simple state, two filaments joined into one, and when several of these naturally compound filaments are combined to make a commercial thread the matter becomes still more difficult. Mr. E. W. Serrell, jr., of New York, has, however, overcome these obstacles by relying on another property of a silk filament, which is, that the distance which a given length will stretch under a given tension is inversely proportionate to the mean cross-section of this length. This is the underlying principle of his serigraph, which will now be described. The mode of testing with this machine is as follows: The end of the thread is brought from the reel or bobbin on which it is wound, around a drum (Fig. 30 *A*), thence over

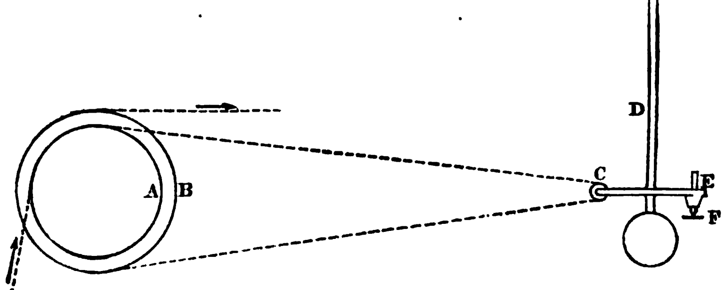

FIG. 30.—The principle of the Serigraph (original).

a pulley, *C*, and back around another drum, *B*, mounted on the same axis as *A*. From the drum *B* it is wound on a reel. The drum *B* is larger than *A*, so that the former winds on the thread somewhat faster than it is paid off by the latter. In thus stretching the thread we apply a force to the pulley *C* tending to draw it from its normal position. This pulley is attached to the base of a pendulum, *D*, which, under the action of the force mentioned, is drawn from the perpendicular. The weight of this pendulum overcoming this applied force to an extent inversely proportional to the mean section of the length of thread submitted to the test, the position of equilibrium taken by the pendulum depends upon that mean section. This length of thread is the piece between the two drums *A* and *B*, and as, through the constant action of the machine, successive lengths of thread occupy the position indicated, the pendulum oscillates through a course which depends upon the irregularities of the thread. These irregularities are graphically recorded by a pencil, *E*, attached to the pendulum, upon a band of paper, *F*, constantly moving under its point. In the commercial form of the machine the mechanism for driving the reel is so constructed as to stop automatically when a standard échevette has been wound upon it, and this échevette may then be sized in the manner above described.

The elasticity and the tenacity of raw silk are determined by the use of the serimeter. This machine is composed of a dynamometer above, a graduated circle indicating the tension corresponding to the point at which the index stops. On the lower extremity of this dynamometer is a knob to which the thread to be tested may be attached. At 50 centimeters below this knob, in the same vertical line, is another knob attached to a counterweight which is on the inside of the case of the instrument and which also bears a pointer moving along a graduated scale on the outside of the case. This weight is held in place by a detent which is terminated on the outside of the case by a faller, on which it is only necessary to press lightly to cause the detent to let go the counterweight and permit its index to slide along the scale; these stop instantly, on the other hand, when the faller is released and retakes its initial position.

The silk thread attached to the two knobs mentioned passes over this faller, and, as it tends to pull it from its normal position, the detent lets go the counterweight and the thread stretches until rupture takes place, when the descent of the counterweight is automatically stopped. It is then only necessary to read the indication of the dynamometer to ascertain the weight which caused the rupture. By doubling the distance passed over by the sliding index, we have the stretch per meter or per cent. of elasticity.

The elasticity or ductility of silk is about 15 to 20 per cent., being nearly four times superior to that of cotton. It is about the same as brass and slightly greater than iron; hair has only half the ductility of silk.

"The tenacity of silk thread is well known; a thread of raw silk of 10 deniers easily supports a weight of 50 grams* without breaking. Direct relations exist between the tenacity of silk, the country in which it originates, its hygrometric state, the processes by which it was reeled, etc. Relations not less interesting may be found between the elasticity and the ductility." †

In the silk which constitutes the cocoon as made by the worm we find three classes of material. They consist of a waxy substance soluble in boiling water, of a gluten soluble in certain acids and alkalies, and especially in a solution of soap, and of the fibrine which constitutes the base of the thread. In the yellow silks there is also a slight quantity of coloring matter. Robinet found from 4 to 5 per cent. of the waxy substance, which, being soluble in boiling water, disappears in the process of reeling. We therefore find in reeled silk the gluten, or, as it is technically called, *grès*, and the fibrine. Before this silk can be properly dyed it is essential that a certain portion of this gluten be removed. This operation is usually performed by boiling it in a solution of soap. At the Conditioning Works at Lyons, France, this boiling off, as it is called, consists of two operations. The silk is first submitted for thirty minutes to ebullition in a solution containing an amount of soap equal in weight to about 25 per cent. of the weight of the silk boiled off. This silk is then wrung, in order to free it from the soap and the dissolved gluten, and then resubmitted to the same operation of boiling. As a result of these tests, it is found that white French silks contain 19.68 per cent. of gluten and the yellow silks 22.84 per cent. Silks coming from Italian filatures contain an amount of gluten slightly in excess of these figures, while the Chinese silks exceed them by more than 2 per cent.

The silk thread is highly hygrometric, containing under ordinary conditions 10 to 12 per cent. of water, while a thread of raw silk is capable of absorbing 21 to 26 per cent. Humidity augments the ductility of silk and slightly diminishes its tenacity.

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* 100,000 times the weight of a piece 50 centimeters long.

† Adrien Perret, "*Monographie de la Condition des Soies de Lyon.*"

CHAPTER X.

FOOD-PLANTS.

The traditional food-plant of the Silk-worm is the Mulberry (botanical genus *Morus*). There are two species of Mulberry indigenous to the United States, namely, the Red Mulberry (*Morus rubra*) and the Small-leaved Mulberry (*Morus parvifolia*), neither of which is suitable Silk-worm food. I have tried in vain to rear the worms upon *rubra*, but they either refuse its leaves entirely or dwindle and soon die upon it. The imported kinds which are most used are the Black (*M. nigra*) and the different varieties of the White (*M. alba*). The first is inferior to the others as Silk-worm food.

The *Moretti*, a variety of the White Mulberry, is profitably grown in the form of a hedge, and the large size of its leaves makes it a very desirable variety.

The *rosea*, *japonica*, and the *multicaulis*, varieties of the same species, are also used with excellent success.

A species of Mulberry new to this country has lately been introduced into the Western States by the Mennonites. This is the Russian Mulberry (*M. tartarica*). It is very hardy and its leaves make excellent Silk-worm food.*

The Mulberry grows readily, being easily propagated by cuttings or layers or from the seed. The white Mulberry, in particular, grows well

*A tree of a genus allied to the Morus is the *Broussonetia papyrifera*, commonly called the Paper Mulberry. It is found quite generally throughout the South, but its foliage is *not* suitable for Silk-worm food. The Paper Mulberry is usually a some what larger tree than the Mulberry and its leaves are subject to a considerable diversity of form, being mainly ovate and toothed on the margin; frequently with lobes on one or both sides of the leaf. They are quite rough to the touch on the upper surface, much more so than the Mulberry, and on the under surface they are softly hairy. The trees are of two kinds, male and female. The male tree, early in the spring before its leaves are developed, has tassels something like those of the willow. They soon drop off after shedding pollen. The female flowers then go on developing during the summer until they make small round balls from which, when ripe, the seeds stand out. These seeds are covered with a gummy substance and are very small, being about the size of those of the raspberry. The female trees are little known in this country, as only the male trees have been introduced into the United States.

I refer to this tree because of the frequency with which inquiries are made by Southern correspondents as to whether the Paper Mulberry can be used as Silk-worm food. The tree is very generally used for shade and ornament in Southern cities, where it attracts attention by the gnarled and knotted character of its trunk.

from cuttings, and this is perhaps the readiest and most economical method of planting to secure a stock.

The cuttings should be started in rows, 3 or 4 inches apart, in ground prepared by deep plowing and harrowing. They should be about 6 inches long, and should be cut just before an eye in every case. They should be almost entirely buried. The quickest way to get a supply of leaves is to grow dwarfs. Set out the young trees from the nursery in rows 10 to 15 feet apart and 6 to 8 feet between the rows, and form the crown of the tree by cutting down to a foot or so from the ground. The height of the tree and its form are easily regulated by pruning, and upon this process depend not only the vigorous growth of the tree, but also the ease with which the leaves may be gathered when desired. The pruning may be done in February or March, either every year or every other year.* All dead twigs and dried bark should be removed and the limbs kept as smooth as possible, as this greatly facilitates picking. The best time for planting is in the fall, from frost until December, and in the spring, from March until May.

For growing standard high trees, a practical raiser gives the following directions: The cutting should remain two years in the nursery without pruning. The third year it is cut close to the ground and transplanted. The finest shoot is then allowed to grow, and in good land it will reach a height of 8 or 10 feet in one season. The fourth year it is cut back to 6 feet or thereabouts. Then, the three or four terminal buds only being allowed to grow, all others are removed as often as they appear by passing the hand along the stem.

It must not be forgotten that in the propagation of plants only true species can be reproduced from the seed. The varieties of the White Mulberry mentioned above can only be obtained from cuttings or layers.

The fresh mulberry leaf contains a large amount of water of vegetation, and of certain mineral and organic matters. Of water, it is only necessary that there should be sufficient to enable the worm to easily digest its food, and all that is in excess of this quantity is apt to be injurious and productive of disease. In order to avoid this difficulty, food-trees should be planted in a light loam, and especial care taken to prevent excessive irrigation. It has been found, too, to be important that the tree should be so planted as to receive as much sunlight as possible, experiments having shown that, other conditions being equal, the leaves of such a tree contained but 55 per cent. of water, while in the case of one lighted by the sun until 1 o'clock only there was 64 per cent., and in one which received only diffused light, 73 per cent.

* The better plan is to have two sets of trees, using each set but once in two years. When pruned a tree is then allowed to grow for one year without touching its leaves, which are only picked for the second season. The life of the tree will thus be materially prolonged, and the crop of leaves be more abundant than with annual pickings.

Of the mineral matter contained in the leaf, only certain portions are appropriated by the worm; these are phosphoric and sulphuric acid, potash, and magnesia. Its silica and sulphate and carbonate of lime are not useful in nutrition. In studying the leaf of the Mulberry at different seasons it is found that early in the spring certain varieties possess these nutritive mineral substances to a greater extent than others, but that as the season advances they become less abundant, while the proportion of silica and lime increases. It is important, then, if from this point of view only, that we should rear our Silk-worms as early in the season as possible. A great many experimenters have occupied themselves with the value of the different varieties of Mulberry with a view to ascertaining which would give the best alimentary results under ordinary conditions. As a result, it is generally advised that the seedling White Mulberry be fed at the beginning of an education and the *rosea* during the later ages. The *multicaulis* possesses many of the advantages of these varieties, though less rich in nutritive elements than either of them.

OSAGE ORANGE.—The cultivation of the Osage Orange (*Maclura aurantiaca*) is so well understood in this country that there is no need of giving detailed instructions on the subject. Very generally used as a hedge-plant in those sections of the country which are particularly adapted to silk culture, its leaves may at once be obtained without any special investment of capital. Indeed, as the hedges need trimming, the cutting off of the new year's growth, as the leaves may be wanted for feeding purposes, is a saving rather than an expenditure. Those who use this plant as Silk-worm food must, however, bear in mind that the shoots from a hedgerow become very vigorous and succulent by the time the worms are in the last age. These more milky and succulent terminal leaves should be thrown aside and not used, as they are apt to induce flaccidity and other diseases.

In avoiding these more tender leaves and using only the older and firmer ones, especially when the worms are large, consists the whole secret of the successful rearing of Silk-worms on this plant; and if care be had in this respect, and the same judgment used in selecting from trees or hedges well exposed to sunlight, as suggested for Mulberry, there will be no appreciable difference in the silk crop from Osage Orange as compared with that from Mulberry.

The thorns of this plant make it somewhat more difficult to pick its leaves than those of the Mulberry, and I should not advise its cultivation merely as Silk-worm food.

What is said of the Osage Orange is based upon a very extended experience, and I would not only emphasize the fact of the value of this plant, but also of the necessity of the careful selection of Maclura leaves, especially during the last two ages of the worm. I have found that after the third age time is saved by using the twigs, first taking care to clip off the spines, which is rapidly done by means of a pair of scissors. In

using twigs instead of leaves, the tender tips of the current year's growth should be cut off with the spines. I have found this method of feeding to have decided advantages (though contrary to all custom in Europe, where the twigs and branches of the Mulberry are too valuable to be constantly pruned), for it not only allows more air to circulate as the food accumulates, but it gives the worms, as they grow in size, an opportunity of clambering about, which they do not have to the same extent where leaves alone are used. In adding the new meal there is, also, where twigs are used, less danger of the transfer paper pressing injuriously upon the worms beneath.

Should the worms, from whatever cause, hatch before either Mulberry or Osage Orange leaves can be obtained, they may be quite successfully fed, for a few days, upon well-dried lettuce leaves. It will, however, be worse than a waste of time to attempt to feed them entirely on these leaves, or, in fact, on any other plants than the two here recommended.

GLOSSARY OF TERMS USED.

Age: The interval between hatching and first molt, between any two molts, or between the last larval molt and spinning.

Alimentary canal: The food canal; a straight, simple tube, running from one end of the body to the other, and which it is impossible to subdivide into gullet, stomach, and intestine.

Alkaline: Having the opposite reactions to an acid.

Anal horn: The horn upon the posterior end of the body of the worm.

Annuals: Those races which produce but one brood in a year.

Antennæ: The feathery feelers upon the head of the moth.

Bacillus: A microscopical vegetable organism, often causing disease.

Bivoltins: Those races producing two broods in one year.

Bombycidæ: The family of moths, commonly known as "spinners," to which the Silk-worm moth belongs.

Botrytis bassiana: The fungus causing muscardine.

Brin: The French term for a single thread from the cocoon.

Carneous: Flesh-colored.

Choked cocoons: A term applied to those cocoons in which the chrysalis has been killed.

Chlorophyl: The green coloring matter of leaves.

Chrysalis: The third or restful state of the insect, or that between the worm and the moth, inclosed in the cocoon.

Cocoon: The silken covering with which the worm surrounds itself before passing into the chrysalis state.

Cocoonery: The name applied to a room or building where cocoons are dried after being choked.

Corpuscle: A microscopic parasitic organism causing the disease, pébrine.

Croisure: The twist to which the silk thread is submitted in reeling.

Dacey: A Bengalese race of worms producing eight broods each year.

Detent: A stop which locks and unlocks the wheels in clock-work.

Dorsal vessel: The heart, extending from one end of the body to the other, just under the skin of the back.

Échevette: A small skein of silk of a determined length, the weight of which determines its size number.

Epizootic: A term having the same significance with lower animals as epidemic with man.

Éprouvette: A reel supplied with a counter upon which échevettes are measured.

Faller: A small lever, over which a thread runs, and which, upon the breaking of the thread, falls, thus stopping the mechanism through the action of a detent to which it is attached,

Fil: The French term for the combined threads as they come from the reel.

Ferment: Micro-organism causing fermentation.

Fibrine: An organic compound forming the base of the silk filament.

Filature: The French name for reeling establishment.

Flaccidity: A Silk-worm disease characterized in the text, Chapter V.

Flacherie: The French name for flaccidity.

Floss silk: Silk made from the loose material of the outer cocoon and from pierced cocoons, etc. It is carded and spun like cotton or wool.

Fresh cocoons: Cocoons that have not been choked.

Gattine: An old name for a mild phase of the disease known as pébrine. Maillot thinks that it is a form of flaccidity.

Grasserie: A Silk-worm disease allied to jaundice. It is described in Chapter V.

Green cocoons: A name frequently applied to fresh or unchoked cocoons. Should be avoided, except where it has reference to cocoons of a green color.

Greens: A name applied to those races making cocoons of a greenish tint.

Integument: Skin or outer covering.

Japonica: A variety of the White Mulberry.

Labium: The under lip, upon which is situated the spinneret.

Larva: The second or worm state of the insect.

Lepidoptera: Name of the order to which the Silk-worm belongs.

Lusettes: A name applied to the worms which die from being unable to molt.

Magnanerie: The name applied to the room or building used for the rearing of worms.

Micropyle: The opening in the egg of the Silk-worm moth through which the fecundating liquid enters.

Moretti: A variety of the White Mulberry discovered in 1815 by Professor Moretti, of Pavia.

Mori: The scientific specific name for the Silk-worm.

Morus: The botanical generic name of the Mulberry.

Multicaulis: A variety of the White Mulberry.

Muscardine: A Silk-worm disease of a fungus nature, characterized in the text, Chapter V.

Spinneret: A tube projecting from the lower lip, and through which the silk issues.
Organzine: Highly twisted thrown silk used in the woof in weaving.
Ovipositing: Laying the eggs.
Pébrine: A Silk-worm disease characterized in the text, Chapter V.
Pod: The compact portion of the cocoon, which is used for reeling purposes.
Polyvoltins: A term applied indiscriminately to all races which produce more than one brood in a year.
Pro-legs: The ten non-jointed legs under the sixth, seventh, eighth, ninth, and last joints of the body of the worm.
Psorospermiæ: Scientific name for the floating corpuscles in the bodies of worms affected by pébrine.
Quadrivoltins: Those races which produce four broods in one year.
Raw silk: Silk reeled from the cocoons before being thrown and woven.
Rosea: A variety of the White Mulberry.
Seed: The eggs in bulk.
Sericaria: A generic name proposed by Latreille, and to which the Silk-worm is referred by modern writers.
Sickness: The period of molting.
Spiracles: The breathing-holes of the insect; one row of nine down each side of the body.
Spores: The germinating seed of fungi.
Tavellette: A small pulley used in the Italian system of reeling.
Thrown silk: Silk which has been submitted to the operations following spinning or reeling. It is classed as tram and organzine.
Trachea: The breathing-tube of an insect.
Tram: Slightly twisted thrown silk used in the warp in weaving.
Transformation: The change from one state to another, as from worm to chrysalis or from chrysalis to moth.
Trevoltins: Those races of Silk-worms of which there are three broods in one year.
Vitellus: The yolk of an egg.
Whites: Those varieties having white cocoons.
Yellows: Those varieties having yellow cocoons.

EXPLANATION TO PLATES.

PLATE I.

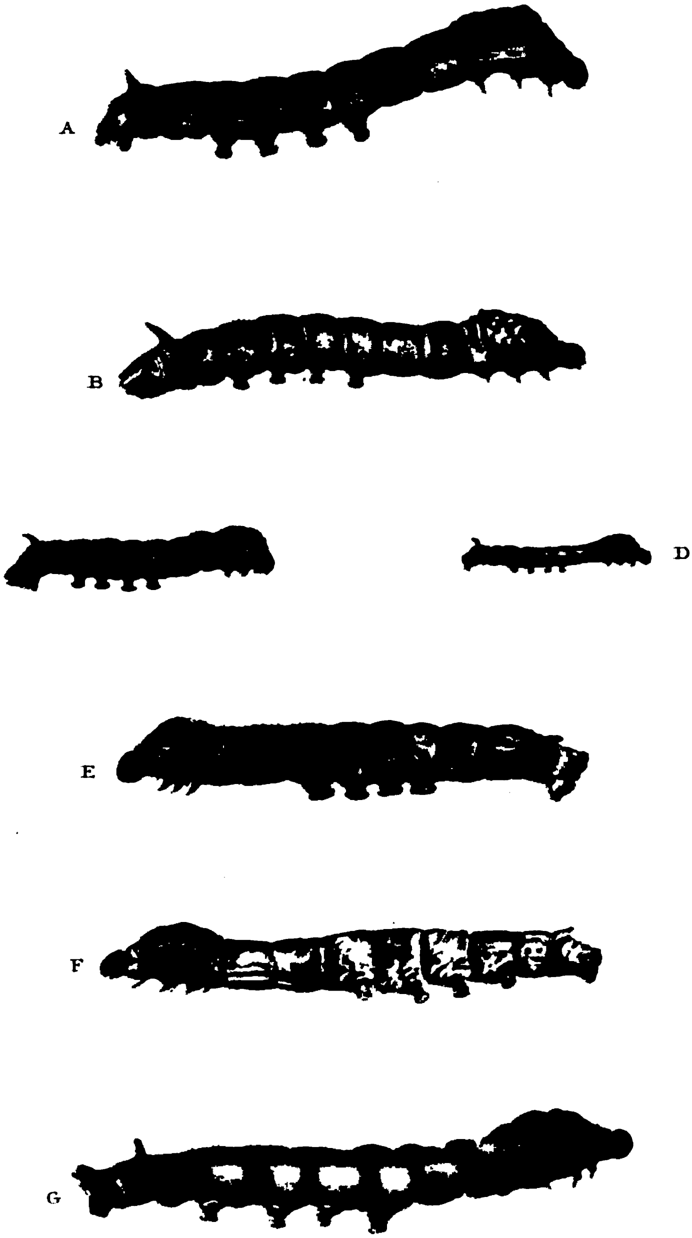
SILK-WORMS AFFECTED BY PÉBRINE AND FLACCIDITY (AFTER PASTEUR).

A, B, C, D, Silk-worms affected with pébrine, showing the spots of the disease. On the eighth joint of the worm A will be seen a wound which is distinguishable by its clear-cut edges.

E, F, G, worms, after death from flaccidity. G shows the worm just after death, still retaining all of its outward perfection of form. At F the worm has begun to shrivel, while at E the blackening caused by putrefaction is shown.

PLATE II.

PÉBRINE CORPUSCLES OF SILK-WORM MOTH HIGHLY MAGNIFIED (AFTER PASTEUR). (The white ovoid bodies are these corpuscles.)



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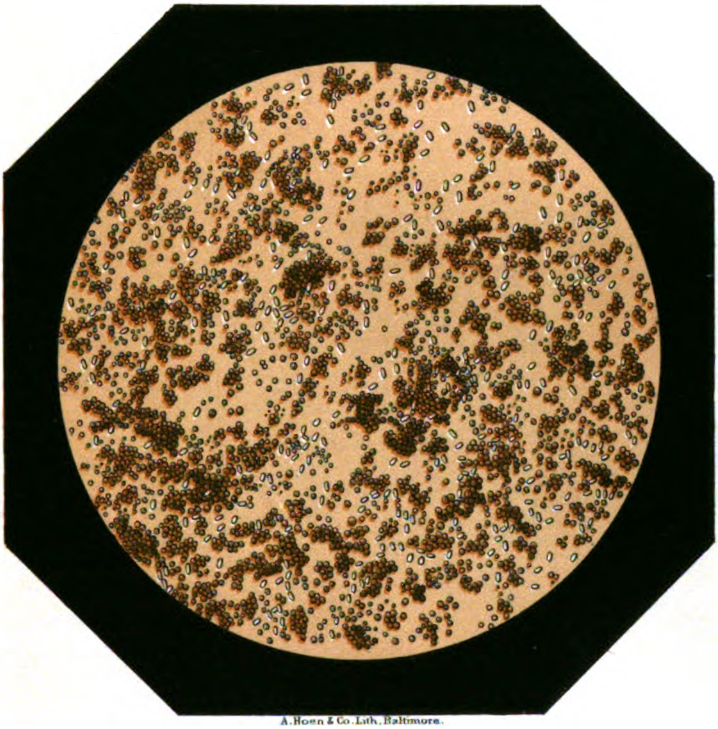
SILKWORMS AFFECTED BY PEBRINE AND FLACCIDITY.

(after PASTEUR)



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PEBRINE CORPUSCULES OF SILKWORM MOTH,

highly magnified.

(after PASTEUR)

INDEX.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 10.
(SECOND, REVISED EDITION.)

OUR SHADE TREES AND THEIR INSECT DEFOLIATORS.

BEING A CONSIDERATION OF THE FOUR MOST INJURIOUS SPECIES WHICH AFFECT THE TREES OF THE CAPITAL; WITH MEANS OF DESTROYING THEM.

BY

C. V. RILEY,
ENTOMOLOGIST.

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DIVISION OF ENTOMOLOGY,
Washington, D. C., March 15, 1887.

SIR: I have the honor to submit for publication Bulletin No. 10 of this Division, being an account of the more important insects which defoliate our shade trees. While of interest to other sections of the country, it has been prepared primarily to supply the constant demand for information by residents of the National Capital. In the series of Bulletins of this Division it takes the place of one on "Bird Migration in the Mississippi Valley," announced a year ago, and which, since the creation of the separate Division of Ornithology and Mammalogy, I have thought best to leave out of the series from the Entomological Division, especially as Dr. Merriam, the Ornithologist, has greatly amplified it.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

INTRODUCTION TO THE FIRST EDITION.

Though all four of the insects considered in this Bulletin have been studied in years gone by and have been treated of in various publications, yet some facts of interest are recorded here for the first time. The article on the Elm Leaf-beetle is reproduced from Bulletin No. 6, which has been for some time out of print. Those on the Bag-worm and on the Tussock-moth are condensed from our First Report as State Entomologist of Missouri, published in 1868, and from later writings, and that on the Fall Web-worm is made up from the Third Report of that series for 1870, but contains much that is new and especially applicable to the District of Columbia, the quoted portions being taken in advance from our forthcoming report to the Department. The Bulletin concludes with some facts and suggestions which are also of local interest and have been elicited by the exceptional concern shown by the people of Washington in the caterpillar nuisance. Some portions of this part of the Bulletin have been given for publication to the Washington *Evening Star*.

In treating of the means of preventing the injury and of preserving the foliage of our trees we have gone into details as to the most important means in considering the first species, or the Elm Leaf-beetle, so as to avoid repetition, and later, in connection with the fourth species or Fall Web-worm, referred briefly to other methods.

C. V. R.

SHADE TREES AND THEIR INSECT DEFOLIATORS.

FOUR PRINCIPAL LEAF-EATERS.

There are four insects principally concerned in the defoliation of the shade trees in the city of Washington. They are: (1) The Imported Elm Leaf-beetle (*Galeruca xanthomelæna*); (2) the Bag-worm (*Thyridopteryx ephemeræformis*); (3) the White-marked Tussock-moth (*Orgyia leucostigma*); and (4) the Fall Web-worm (*Hyphantria cunea*).

THE IMPORTED ELM LEAF-BEETLE.

(*Galeruca xanthomelæna** Schrank.)

The depredations of this pest have now become widely extended throughout the Northeastern States, rendering almost worthless and unsightly those most valuable shade trees of our cities—the elms. As its injuries are so far unknown in the Mississippi Valley, the blighted appearance of the elms on the Department grounds in midsummer, and especially of the European varieties, at once attracted our attention when we first came to Washington, and a series of experiments was begun with a view of checking the ravages of the insect. The excellent opportunites thus offered for experiment and study have since been improved, and, with some prefatory passages in relation to the history and habits of the beetle, we will give the practical results reached.

AN IMPORTATION FROM EUROPE.

This beetle has done great mischief in the Old World, especially in Germany and France, and it is very important that the public know the best method of coping with it here. According to Glover, it was imported as early as 1837. Its distribution was formerly confined to limited areas near the coast, and its earlier attacks were notably about Baltimore and New Jersey.

HABITS AND NATURAL HISTORY.

The general characteristics of this insect have been pretty well studied abroad. Mr. E. Heeger† has given an excellent account of its life-history, with a detailed description of the larva and figures illus-

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* This is the *Galeruca cratægi* Först., and *G. calmariensis* Fabr. In Crotch's Check-list it appears as *Galerucella xanthomelæna*.

† Seventieth contribution to the natural history of insects. Sitzungsberichte der kais. Ac. Wiss., Wien, 1858, vol. 29.

trating larva and pupa, and anatomical details. More recently M. Maurice Girard* has given a rather poor wood-cut illustration of the insect and its work, with the leading facts concerning its nomenclature and natural history as observed in Europe. Biological notes on the insect have also been given by Leinweber† and Kollar.‡

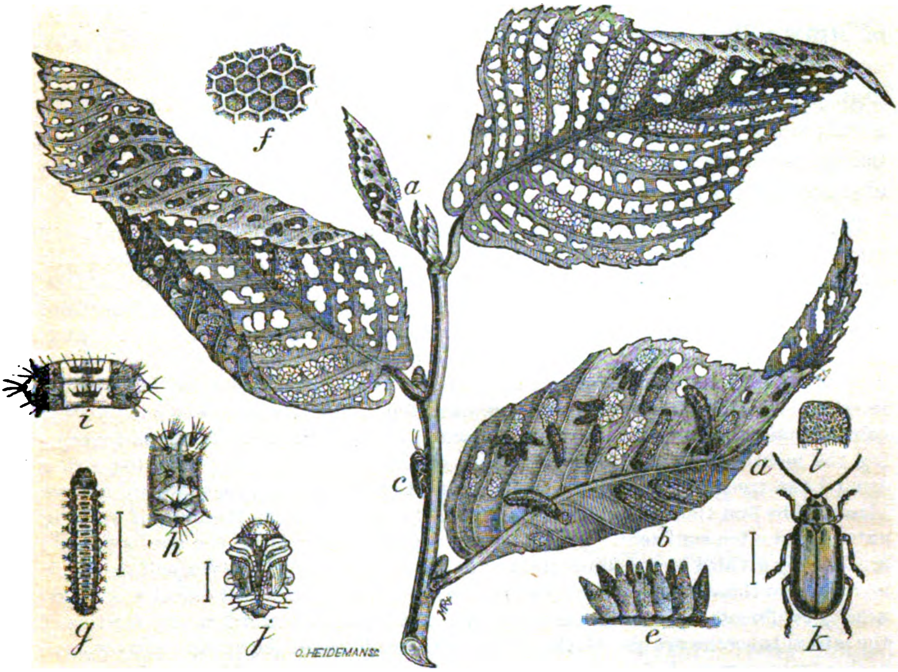

FIG. 1.—*Galeruca xanthomelæna*; *a*, eggs; *b*, larvæ; *c*, adult; *e*, eggs (enlarged); *f*, sculpture of eggs; *g*, larva (enlarged): *h*, side view of greatly enlarged segment of larva; *i*, dorsal view of same; *j*, pupa (enlarged); *k*, beetle (enlarged); *l*, portion of elytron of beetle (greatly enlarged).

In our country the life-history of the insect and its injury have been referred to by Harris, Fitch, Morris, Walsh, and ourselves, while the agricultural papers contain numerous references to the injury inflicted by the insect. The perfect beetle has often been described in systematic works on Coleoptera.

For these reasons we deem it unnecessary to enter here into a detailed description of the beetle and its earlier stages, but content ourselves with pointing out the more obvious characters, alluding to such facts of the life-history as are necessary to a full understanding of the nature of the remedies to be applied for this pest.

The eggs are deposited in an upright position upon the under side of the leaves (Fig. 1 *a*), always in a group, consisting generally of two, rarely three, more or less irregular rows. The individual eggs are close

* Note sur la Galéruque de l'orme, Bull. d'Insectologie Agricole, VIII, pp. 113–116.

† Verhandlungen zoöl.-bot., Ges., Wien, 1856, VI, Sitzb., pp.74, 75.

‡ *Op. cit.*, 1858, VIII, pp.29, 30.

together in each group (Fig. 1 *e*, magnified), and so firmly fastened to the leaf that they can only be detached with great care without breaking the thin and brittle shell. The number of eggs in each group varies from four or five to twenty or more. Very rarely only three eggs are seen in one group, but we never found less than that number. The egg itself is oblong, oval, obtusely, but not abruptly, pointed at tip, of straw-yellow color, its surface being opake and beautifully and evenly reticulated, each mesh forming a regular hexagon, as shown, highly magnified, in Fig. 1 *f*. The form of the eggs is not quite constant, some of them, especially those in the middle of a large group, being much narrower than others. The duration of the egg-state is about one week.

The general shape of the larva is very elongate, almost cylindrical, and distinctly tapering posteriorly in the early stages, but less convex, and of nearly equal width when mature. The general color of the young larva is yellowish-black, with the black markings comparatively larger and more conspicuous, and with the hairs arising from these markings much longer and stiffer than in the full-grown larva. With each consecutive molt the yellow color becomes more marked, the black markings of less extent and of less intense color, and the hairs much shorter, sparser, and lighter in color. A nearly full-grown larva is represented in Fig. 1 *g*, and in this the yellow color occupies a wide dorsal stripe and a lateral stripe each side. The head (excepting the mouth parts and anterior margin of the front), the legs (excepting a ring around the trochanters), and the posterior portion of the anal segment, are always black. The first thoracic segment has two large black spots on the disk, of varying extent, and often confluent. The following segments (excepting the anal segment) are dorsally divided by a shallow transverse impression into two halves, and the black markings on these halves are arranged as follows: Two transversal dorsal markings, usually confluent, as shown in our figure; two round and sublateral spots; the tips of the lateral tubercles are also black. The abdominal joints of the ventral surface have each a transverse medial mark, and two round sublateral spots of black color. Stigmata visible as small umbilicate spots between outer sublateral series of dorsal markings and lateral tubercles. The yellow parts of the upper side are opake, but those of the under side shining. The black markings are polished, piliferous, and raised above the remaining portions of the body.

The larvæ are destructive to the foliage from the month of May until August. They have about two weeks of active life between the egg and pupa states. During this time they prey upon the leaves, which become skeletonized, leaving the venation, and commonly a certain portion of the flesh of the leaf, which becomes rust-brown. They undergo four molts, respectively observed at Washington on July 15 (at hatching) 20, 23, and 29 (pupation). When full grown they descend to the ground and change to pupa under whatever shelter is near to the base of the tree.

The pupa (Fig. 1 *j*) is of a brighter color than the larva, oval in shape, and strongly convex dorsally. It is sparsely covered with moderately long but very conspicuous black bristles, irregularly arranged on head and thorax, but in a transverse row on each following segment. The pupa state lasts about from 6–10 days.

The perfect beetle (Fig. 1 *c*, natural size; *k* magnified) resembles somewhat in appearance the well known striped cucumber-beetle (*Diabrotica vittata*), but is at once

distinguished by the elytra not being striate-punctate but simply rugose, the sculpture under high magnifying being represented in Fig. 1 *l*. The color of the upper side is pale yellow or yellowish-brown, with the following parts black: on the head a frontal (often wanting) and a vertical spot; three spots on the thorax; on the elytra a narrow stripe along the suture, a short, often indistinct scutellar stria each side, and a wider humeral stripe not reaching the tip. Under side black, pro and mesosternum and legs yellow, femora with a black apical spot. Upper and under side covered with very fine, short, silky hairs. In newly-hatched individuals the black markings have a greenish tint; the humeral stripe varies in extent.

The beetle assists the larva in its destructive work, but, as usual in such cases, the damage done by the perfect insect is small when compared with that done by the larva. There are three or four annual generations of the insect, according to the character of the season. In the month of September the beetles prepare for hibernation, seeking shelter in hollow trees, in the ground, under old leaves, &c., and remain dormant until the following spring.

REMEDIES.

M. Girard says:

There is no other means of destruction than to jar the branches over cloths to collect the larvæ and adults which fall. It is also possible when they are on the ground to distribute on them boiling water or steam, or even quick-lime or solution of sulphocarbonate of potassium.

In our own country much more has been accomplished toward practically combating this insect.

In the U. S. Agricultural Report of 1867, Glover suggested the use of oil and tar gutters and other barriers surrounding the base or the body of the tree, devices similar to those used against the canker-worm and codling-moth. He then and afterward (1870) recommended "to place around each tree small, tight, square boxes or frames, a foot or 18 inches in height, sunk in the earth; the ground within the inclosure to be covered with cement, and the top edge of each frame to be covered with broad, projecting pieces of tin, like the eaves of a house or the letter T, or painted with some adhesive or repellant substance, as tar, &c. The larvæ descending the tree, being unable to climb over the inclosure, would change into helpless pupæ within the box, where they could daily be destroyed by thousands. Those hiding within the crevices of the bark of the trunk could easily be syringed from their hiding places." (U. S. Agricultural Report, 1870, pp. 73, 74.) These boxes were carefully tested at this Department, and they worked as described. While coal-tar and other adhesives were recommended, we have found scalding-hot water most convenient for destroying the insects that accumulate in the inclosure or upon the ground elsewhere. Where branches are low and droop near the ground some of the larvæ descend the wrong way and fall off, but shade trees should not be allowed to grow in this low, drooping manner, and under all ordinary circumstances, where the branches are not severely jarred to encourage the insects to drop, the larvæ will descend by the trunk and become captured in the devices here noticed.

Mr. Glover regarded the pupa state as the most favorable in which to kill the insect, as it can then be easily crushed or scalded. Concerning the tobacco treatment he adds that "syringing the trees with strong tobacco water has been tried with some good effect, but the larvæ not touched by the fluid are merely knocked down by the concussion, and, if nearly ready to change into pupæ, effect their transformation where they fall."

In this connection we cannot do better than quote what we published in 1880* in reply to certain statements by Dr. J. L. Le Conte, as follows:

Anent *Galeruca xanthomelæna*, which is becoming more destructive each successive year to the shade elms in our northern towns, a correspondent mentions the following facts:

1. The trees are not all attacked at the same time, but the insect seems to break out from a center, gradually destroying the more remote trees, so that isolated trees remain comparatively free.

2. After applying a band (saturated with fish-oil, petroleum, &c.) to some trees which were about half denuded, found hundreds of the worms stopped both in ascending and descending the trees.

He also propounded the following query:

3. Do the beetles hibernate in the ground, so that they can be poisoned, or are they perpetuated only by the eggs on the trees:

Allow me to add the following subjects for investigation as necessary to the devising of proper remedies against this foreign invader:

4. How soon do the insects appear in the spring; how rapidly do they propagate; and what time is passed in each stage of development?

5. Are the larvæ and beetles eaten by insectivorous birds, or are they protected by offensive secretions, as is the case with *Doryphora 10-lineata*, *Orgyia leucostigma*, and several other noxious insects?

6. What proportion of the brood hibernates, and in what stage, pupa or perfect insect, and where?

If the materials for furnishing answers to these questions are not yet within your reach, will you kindly direct the attention of some of your trusty observers to the subject, so that persons interested in the preservation of the shade trees which are so justly esteemed may be properly instructed as to the measures to be adopted during the next summer.

Very truly, yours,

J. L. LE CONTE,
Philadelphia, Pa.

The above inquiries were received from our esteemed correspondent some time since, and we employ them as a ready means of giving our experience with the beetle.

For the benefit of the general reader it may be remarked that the natural history of this Elm Leaf-beetle is quite similar to that of the well-known Colorado Potato-beetle and of the Grape-vine Flea-beetle. The only deviation in the Elm Leaf-beetle is in the mode of pupation, which rarely takes place in the ground, unless this be very friable, but at the base of the tree or under any shelter that may present itself near the trees, such as old leaves, grass, &c.

(1) The phenomenon here described is doubtless due to the gradual increase in spring from one or more females.

(3 and 6) Like most, if not all, *Chrysomelidæ*, the Elm Leaf-beetle hibernates in the perfect state. As places suitable for hibernation abound, any attempt to successfully

* *American Entomologist*, December, 1880, p. 291.

fight this pest in winter time, with a view of preventing its ravages the subsequent season, will prove fruitless. A large proportion of the hibernating beetles doubtless perish, since the insect is comparatively scarce in the earlier part of the season.

(4 and 5) The beetles fly as soon as spring opens, and we have observed the first larvæ early in May,* in Washington, D. C., or some time after the elm leaves are fully developed. The ravages of the insect begin to be apparent with the second generation of larvæ, which appear in June.

In 1878 we made many notes and experiments on the species, and the development of the third and most injurious generation occupied about one month. The numerous pupæ, which in the latter part of August were to be found under the trees, were mostly destroyed that year, partly by continuous wet weather prevailing at the time, partly by the many enemies of the insect. Among these there are *Platynus punctiformis* and *Quedius molochinus*, which feed on the full-grown larvæ when these retire for pupation, and also on the pupæ. The larva of a *Chrysopa* (probably *C. rufilabris*) feeds upon the eggs of the *Galeruca; Reduvius novenarius* sucks both beetles and larvæ on the leaves, while *Mantis carolina* preys upon the beetle. Of the numerous other insects found among the pupæ under the trees, *e. g. Tachyporus jocosus*, sundry spiders, myriapods, &c., several are doubtless enemies of the *Galeruca*, though we have, as yet, no proof of the fact. Many birds were observed on the trees infested by the beetles, but the English sparrow, which was the most numerous, did not feed on the insect in any stage of growth.

The only method of warfare against this pest recommended by European writers is to jar the larvæ down onto sheets, and then in one way or another to destroy them. This may answer for young trees, but is then tedious and but partial. We found that the quickest and most satisfactory way of destroying the insect and protecting the trees was by the use of Paris green and water in the manner frequently recommended in these columns, and London purple will evidently prove just as effectual and cheaper. The syringing cannot be done from the ground except on very young trees, though a good fountain pump will throw a spray nearly 30 feet high. Larger trees will have to be ascended by means of a ladder and the liquid sprinkled or atomized through one of the portable atomizers, like Peck's, which is fastened to the body and contains 3 gallons of the liquid.

The mode of pupation of the insect under the tree, on the surface of the ground, beneath whatever shelter it can find, or in the crevices between the earth and the trunk, enables us to kill vast numbers of the pupæ and transforming larvæ by pouring hot water over them. We found that even Paris-green water poured over them also killed. If the trees stand on the sidewalk of the streets the larvæ will go for pupation in the cracks between the bricks or at the base of the tree, where they can also be killed in the same way. This mode of destruction is, take it all in all, the next most satisfactory one we know of, though it must be frequently repeated.

(2) We have largely experimented with a view of intercepting and destroying the larvæ in their descent from the tree. Troughs, such as are used for canker-worms, tarred paper, felt bands saturated with oil, are all good and the means of destroying large numbers. Care must be taken, however, that the oil does not come in contact with the trees, as it will soon kill them, and when felt bandages are used there should be a strip of tin or zinc beneath them. The trouble with all these intercepting devices, however, is that many larvæ let themselves drop down direct from the tree and thus escape destruction.

In conclusion we would remark that it is highly probable that Pyrethrum powder stirred up in water might be successfully substituted for arsenical poisons, but experiments in this direction have not yet been made. From experiments we have made with dry, unmixed powder, we found that it affects very quickly the larva, pupa, and the perfect insect, but in order to be applied on a large scale and on large trees the powder must of course be mixed in water. There is, however, no danger in the judicious use of the arsenical liquids upon shade trees.

* Some years, in Washington, it is the end of May before any larvæ hatch, and the time varies, of course, with latitude and season.

MORE RECENT EXPERIENCE AT THE DEPARTMENT.

The more recent experience in the destruction of this Galeruca on the Department grounds may now be summed up, the experiments having been intrusted to Dr. Barnard.

Past History of the Elms in question.—According to Mr. William Saunders, of this Department, these trees have been annually attacked by the European Elm Leaf-beetle since they were planted ten years ago, and about one year in three the injury has been severe, resulting in their defoliation, while in other years, as in 1879 and 1880, there appeared comparatively none. In some seasons a second or autumnal set of leaves appeared after the trees had been stripped, and in certain of these instances the second crop of leaves became eaten; but in all cases he thinks the lives of the trees have not seemed to be endangered and they soon repaired the damage done. His belief is also that the pest did not become gradually worse and worse through the series of years during which it has been observed by him, still he regards the attack of 1882 as worse than any known to him before on these trees or others, and he has noticed the effects of this insect since 1850, first in its earliest ravages about Baltimore, and later elsewhere.

Condition and Characteristics of the Grove in 1882 *and* 1883.—However it may be for the past history or future desirability of certain trees in the grove, in 1882 many exhibited various grades of feebleness, and some had dying branches. Indeed, a few of them had a very unhealthy aspect the previous year also. Of course it can be claimed that their unhealthy condition is due to other causes than the insects; and it should be remembered that most are foreign species, each often represented in two or more of its varieties. Here all grow on level ground, whereas in a state of nature some belong to mountainous localities; others to the damp climate of England, &c. Therefore, many of them are growing under abnormal conditions. They exhibit much variety in the relative abundance, size, form, and texture of the leaves. There is also great diversity in the density and form of branching.

Extent of Injury in 1882 *and* 1883.—All the varieties and species of elms in this grove, without exception, were preyed upon by the pest in 1882 and 1883. The insect, however, showed decided preferences for certain individual trees, varieties, or species, stripping some completely before doing more than very slight harm to the leaves of others, the former becoming completely eaten in midsummer, the latter not until toward the close of the season, or remaining only slightly damaged until then. In 1882 the leaves were eaten faster than they could be developed, and the insect continued abundant enough to prevent a second crop of foliage until in November, when it became too cold for the leaves and active insects to exist.

On these grounds the southeast half of each tree has suffered more than the northwest half. This peculiarity has been very strongly pronounced this year, 1883, on all the trees affected, and upon some exam-

ples far more markedly than upon others. This one-sidedness is especially apparent in the trees which were the most severely eaten. Some trees show the southeast side completely devoured, but the northwest side only half consumed and comparatively green. Such are average cases.

The inferences have been, that the shade, dampness, and coolness of the tree on the northwest side during the morning is too unhealthy for the favorable development of the larvæ or of the eggs deposited there; but whether this be true or not, the insect probably prefers to deposit chiefly in the middle of the forenoon, and on that part of the tree which is then warmest. This would give a greater number of the eggs at the outset on the southeast side, as observation seems to confirm, and since the young larvæ do not migrate to any noteworthy extent, the one-sidedness described would result, whether the northwest side were unhealthy or not. The former explanation is most probably the correct one, as we have noticed that the insect is less injurious during very wet summers.

Preferences of the Elm-beetles for certain Varieties and Species of Elms.—The American Slippery Elm does not occur in this grove, but only one native species, the common American Elm, *Ulmus americana.* This is practically free from the ravages of the beetle, on which account it may be preferred to the European species. It is tall, and has gracefully arched branches, making it as ornamental as any European kind, yet as a shade tree it does not equal the *U. montana* of the Old World. The latter has a broader, denser crown, but the attack on it is considerable, enough to leave the choice in favor of the American species.

U. montana seems the best European species grown here for shade, since the other foreign elms here cultivated are not dense enough. This applies to *U. campestris*, *U. suberosa*, *U. effusa*, and *U. parvifolia* (*siberica*). The last named is not attacked as much as the American. The young larvæ cannot develop on it, but die quite soon, without growing, and they gnaw the leaves very little. The other foreign species mentioned are seriously eaten; the severest attack being upon the *U. campestris*, the favorite food of this insect.

As early as June 25, in 1883, this species was completely eaten and brown in our grove, at which date the *U. montana* examples retained more than half their verdure; in some individuals nearly all; and the common American elm was perfectly green. The *U. campestris* is one of the poorest elms for shade, and its total abolishment throughout the entire country would probably lessen the assault on *U. montana* to a comparatively unobjectionable extent. This measure should be instituted against the pest, and for the sake of the other species of elms.

Effects of arsenical Poisons on Insect and Plant.—Species of elms are somewhat differently affected by the poison. When treated alike there is always manifest some difference in the susceptibility of different elms to the corrosive effects of the poison. Even individuals of the same

species or variety are differently impaired. As a rule, those which suit the insect best are injured most by the poison, and those which resist the insect most withstand the poison best. The latter have coarser foliage with a darker green color and more vigorous general growth; the former have more delicate foliage, lighter in color and weight, apparently less succulent.

Certain elms of the species *U. campestris* and other species which were overpoisoned, and shed most of their leaves in consequence, in the last of June, 1883, sent out a profuse new growth of leaves and twigs. The foliage fell gradually for three weeks, and this was somewhat promoted by the succeeding rains.

The larvæ move from place to place so seldom that if the leaves are imperfectly poisoned from the mixture being weakly diluted, or from its application only in large, scattered drops, which are much avoided by the larvæ, they are not killed off thoroughly for several days, and in all cases it requires considerable time to attain the full effect of the poison. This result appears on the plant and on the insect. After each rain the poison takes a new effect upon the plant and the pest, which indicates that the poison is absorbed more or is more active when wet, and that it acts by dehydrating thereafter. Where the tree is too strongly poisoned, each rain causes a new lot of leaves to become discolored by the poison or to fall. On some of the trees the discoloration appears in brown, dead blotches on the foliage, chiefly about the gnawed places and margins, while in other instances many of the leaves turn yellow, and others fall without change of color. The latter may not all drop from the effects of poison, but the coloration referred to is without doubt generally from the caustic action. The poison not only produces the local effects from contact action on the parts touched by it, but following this there appears a more general effect, manifest in that all the foliage appears to lose, to some extent, its freshness and vitality. This secondary influence is probably from poisoning of the sap in a moderate degree. When this is once observable, no leaf-eater thrives upon the foliage. Slight overpoisoning seems to have a tonic or invigorating effect on the tree.

Preventive Effects of the Poison.—In this grove the elms that were poisoned in 1882 were attacked in the spring of 1883 less severely than were those which were not poisoned the previous year. This would seem to imply that the insects deposit mostly on the trees nearest to where they develop, and are only partially migratory before ovipositing. The attack afterward became increased, probably by immigration and the new generation, so that later in the season the trees were mostly infested to the usual extent.

In the region of Washington *a preventive application of poison should be made* before the last of May or first of June, when the eggs are being deposited and before they hatch. This will prevent the worms from ever getting a start. By the preventive method the tree escapes two

kinds of injury; first, that directly from the eating by the insect; second, that which follows indirectly from the deleterious effects of the poison on the plant, for its caustic effect is much greater where the leaves have been so gnawed that the poison comes in contact with the sap.

Treatment with London purple.—Already early in June the insect appears plentiful. On June 7, 1882, it was at work on all the trees, and its clusters of eggs were numerous beneath the leaves. Some of the trees had half of the leaves considerably gnawed and perforated by larvæ of all sizes, and by the adults. At this date fifteen trees, constituting the south part of the grove, were treated.

Preparation of the Poison.—London purple (one-half pound), flour (3 quarts), and water (barrel, 40 gallons) were mixed, as follows: A large galvanized iron funnel of thirteen quarts capacity, and having a cross-septum of fine wire gauze, such as is used for sieves, also having vertical sides, and a rim to keep it from rocking on the barrel, was used. About three quarts of cheap flour were placed in the funnel and washed through the wire gauze by water poured in. The flour in passing through is finely divided, and will diffuse in the water without appearing in lumps. The flour is a suitable medium to make the poison adhesive. The London purple is then placed upon the gauze and washed in by the remainder of the water until the barrel is filled. In other tests the flour was mixed dry with the poison powder, and both were afterward washed through together with good results. It is thought that by mixing in this way less flour will suffice. Three-eighths of a pound of London purple to one barrel of water may be taken as a suitable percentage. Three-eighths of an ounce may be used as an equivalent in one bucketful of water. The amount of this poison was reduced to one-fourth of a pound to the barrel with good effect, but this seems to be the minimum quantity, and to be of value it must be applied in favorable weather and with unusual thoroughness. With one-half or three-fourths of a pound to the barrel, about the maximum strength allowable is attained, and this should be applied only as an extremely fine mist, without drenching the foliage.

Effects of the Mixture.—The flour seems to keep the poison from taking effect on the leaf, preventing to some extent the corrosive injury which otherwise obtains when the poison is coarsely sprinkled or too strong. It also renders the poison more permanent. On the leaves, especially on the under surfaces, the London purple and flour can be seen for several weeks after it has been applied, and the insect is not only destroyed, but is prevented from reappearing, at least for a long period. By poisoning again, a few weeks later, the insect is deterred with greater certainty for the entire season. By being careful to administer the poison before the insect has worked, and, above all, to diffuse the spray finely but not in large drops, no harm worth mention-

ing will accrue to the plant from the proportion of poison recommended. The new growth, that developed after the first poisoning, was protected by one-fourth of a pound to the barrel in 1882. From midsummer until autumn the unpoisoned half of the grove remainded denuded of foliage, while the poisoned half retained its verdure. The little damage then appearing in the protected part was mostly done before the first treatment. Eggs were laid abundantly throughout the season. Many of these seemed unhealthy and failed to develop, probably because they were poisoned. Many hatched, but the young larvæ soon died. The eggs were seldom deposited on the young leaves that were appearing after the poison was applied, but were attached to the developed leaves, and here the larvæ generally got the poison to prevent their attack upon the aftergrowth. Still the young leaves became perforated to some extent. The adults, which fly from tree to tree, appeared plentifully without much interruption throughout the season, and often several could be seen feeding on each tree. Possibly many of these may have become poisoned before depositing the eggs.

The efficiency of London purple being established, it will generally be preferred to other arsenicals, because of its cheapness, better diffusibility, visibility on the foliage, &c. As the effects of the poisons commonly do not appear decidedly for two or three days after their administration, the importance of the preventive method of poisoning in advance cannot be too strongly urged. As the effect is slow in appearing, impatient parties will be apt to repoison on the second or third day, and thus put on enough to hurt the plant when the effect does come. Much depends on dryness or wetness of the weather; but good effects may be expected by the third or fourth day.

London purple seems to injure the plant less than Paris green.

Treatment with Paris green.—In 1883 the Paris green was first applied on the 29th of May, at which date the eggs were extremely abundant and hatching rapidly on the leaves. Paris green, flour, and water were mixed by the means previously employed with London purple and already described. The mixture was applied to the north part of the same grove of elms. Thus far experience shows that the Paris green is effective against the insect, but that this poison injures the plant more than does the London purple.

Three-fourths of a pound of Paris green to a barrel (36 or 40 gallons) of water, with 3 quarts of flour, may be regarded as a poison mixture of medium or average strength for treating elms against these beetles, and the indications thus far are that the amount of Paris green should not be increased above one pound or be diminished much below one-half a pound in this mixture. To a bucketful of water three-fourths of an ounce of Paris green may be used. The action of this poison is slow but severe, and varies much with the weather. Thus far the results of tests have been varied so much by the weather and different modes of preparation and application that they will be repeated. When

used strong enough to cauterize the leaves the poisonous action upon the plant may be observed to continue for several weeks.

Mechanical Means of applying the Poison.—When many trees were to be sprayed a cart or wagon was employed to haul the poison in a large barrel provided with a stirrer, force-pump, skid, &c. The following brief account of the skid, mixer, barrel, and pump may be reproduced here from our Annual Report for 1882:

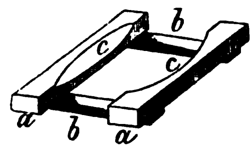

FIG. 2.—*Barrel rest or skid;* two coupling cleats, *b b;* two side rests, *a a;* chamfered concave, *c c.*

The skid is a simple frame to hold the horizontal barrel from rolling, and consists of two pieces (Fig. 2 *a a*) of wood, about the length of the barrel, and in section about 3 by 4 inches, joined parallel, apart from each other, by two cleats, *b b.* The inner upper angles may be cut to match the curve of the barrel, as at *c c.* The barrel being placed upon this frame is next to be filled.

A good device for mixing the poison thoroughly with the water and for filling the barrel is shown in section in Fig. 3. It consists of a large funnel that will hold a bucketful, and has cylindrical sides, *g g,* that rest conformant on the barrel. In this is a gauze or finely perforated diaphragm, or septum, *d,* and a funnel base, *t t,* with its spout, *p,* inserted through the bung.

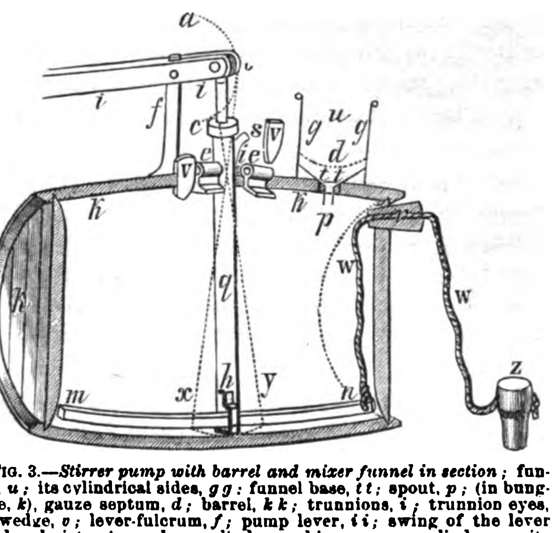

FIG. 3.—*Stirrer pump with barrel and mixer funnel in section;* funnel, *u;* its cylindrical sides, *g g;* funnel base, *t t;* spout, *p;* (in bung-hole, *k*), gauze septum, *d;* barrel, *k k;* trunnions, *i;* trunnion eyes, *e;* wedge, *v;* lever-fulcrum, *f;* pump lever, *i i;* swing of the lever head and piston top, *a b c;* cylinder packing cap, *c;* cylinder, *q;* its swing, *x y;* stirrer loop or eye, *h;* stirrer bar, *m n;* rope, *w w;* bung, *r z.*

By reference to Fig. 3, the barrel, *k,* will be seen in section, and some of its details, together with those of the pump and stirrer, may be noticed. The fulcrum, *f,* has a foot below, screwed to the barrel. Through its top is a pivot, *o,* on which tilts the pump-lever, *l,* which is similarly hinged at *b* to the top of the piston-rod, *t.* The pump-cylinder, *g,* is also hung upon trunnions, *i,* projecting into eyes. In this illustration the eyes, *e e,* have each a neck fitting in a slot cut through the stave, opposite from the side of the bung-hole, and beneath the stave is a foot on the eye-piece. Its neck is so short that the eye is held down firmly against the top of the stave, while the foot is as tight against its under surface. The length of its eye-piece is a little less than the diameter of the bung-hole, into which it may be inserted to be

driver laterally into the slot. The slot is longer than the eye-piece, so the latter may be driven away from the bung-hole for a distance greater than the length of the trunnion pivot. Then the pump being inserted, until these pivots come opposite the eyes, the latter may be driven back as sockets over the pivots, which play in them when the pump is worked. To hold these eyes toward the pump and upon the trunnions a wedge, *r*, is driven in the slot beyond each eye-piece. Thus the pump is easily attached or removed, and its union with the barrel is strong and firm. Perchance it be desired that this pump-hole be bunged, the side slots may be wedged to make the barrel tight.

The parts of the pump being hung as described, the hinge, *b*, forms a toggle-joint, and in its action causes the pump to oscillate on its trunnions, its basal end swinging wider than its top, as indicated by the dotted line from *x* to *y*. Upon the extremity of this swinging end is a loop, *h*, through which is passed the stirrer-bar, *m n*, made to sweep back and forth in the lower side of the barrel, thus to agitate and mix the substances considerably during the operation of the pump, every stroke of the handle causing one or two strokes of the stirrer.

The method of inserting and extricating the stirrer-bar is as follows · It is raised with the pump until the end, *m*, comes opposite the bung-hole, *x*, through which the bar may be pulled out by the cord, *w*, which is attached to the end, *n*. and also preferably to the bungs *r* and *z*, as shown. Through the same hole the bar may be inserted. This stirring device is the simplest in construction and operation of any yet contrived. While working as it does with reference to the concavity of the barrel it is perfectly effective.

The pump is double-acting and very powerful, giving strong pressure to disperse the liquid far and finely, for, with the eddy-chamber nozzle used, the greater the pressure the finer is the liquid atomized. A block or other catch may be fixed on the side of the barrel to fit against the skid and prevent the barrel from rocking therein, as might otherwise happen when it is nearly empty if much power is applied. About one pailful of poisoned water was sprayed upon each tree. When only two or three trees were to be treated an Aquapult or other bucket-pump was used to force the poison from a bucket carried by hand. The Paris-green mixture needs to be almost constantly stirred, as this poison precipitates quickly; but with London purple the agitation is only occasionally necessary.

Connected with either pump is a long, flexible pipe, with its distal part stiff, and serving as a long handle whereby to hold its terminal nozzle beneath the branches or very high up at a comfortable distance from the person managing it. Parts of one form of this extension pipe are shown in Figs. 4 and 5.

To the pump spout is attached the long, 2-ply, flexile hose, *h h*, of ¼-inch caliber. Its considerable length, 12 feet or more, allows the nozzle to be carried about the tree without moving the pump. Beyond its flexile part the hose, *h*, passes through a bamboo pole, *b*, from which the septa have been burned out by a hot iron rod. At the distal end of the pole the hose terminates in a nozzle, *n* or *m*. When the nozzle is in its natural position, *m*, the spray, *z*, is thrown straight ahead, and this suits well for spraying very high branches, but for spraying the under surfaces of the lower parts of the tree it is necessary that the nozzle discharge laterally from the pipe, and this is accomplished with a noz-

zle having a direct discharge by bending it to one side. The nozzle, *n*, and spray, *s*, are directed laterally, and the nozzle, *n*, is maintained in this position by a metallic hook or eye, *v*, having a crooked stem inserted at the side of the hose in the end of the pole. Where the side spray is permanently desired, the metallic stem is inserted inside the hose and connected with the base of the nozzle, or the tubular stem of the nozzle is given the desired crook. For small trees the simpler extension pipe shown in Fig. 5 is satisfactory The metallic tube, *t*, several feet in length, is used as the stiff part, *t*, connected with the hose, *h*. One longer metallic pipe, having telescopic sections made tight by outside segments of rubber tubing, has also been employed, and is a very desirable extension pipe. Where only low end-spraying is to be done, as upon small trees, &c., the eddy-chamber nozzle (Fig. 6) is set upon such a pipe, or upon its own stem, so as to discharge at right angles therefrom; but a diagonal position of the chamber, *n*, on its stem, *i*, throws the spray, *s*, at an intermediate angle between the right angle and a direct line, by which, without any readjustment, the spray, *s*, can be directed higher or lower, beneath the foliage or above. For general use, this kind of nozzle is the best. It consists of a shallow, circular, metal-chamber (Fig. 6, *c*), soldered to a short piece of metal tubing, *a*, as an inlet. The inlet passage, *x*, penetrates the wall of the chamber tangentially, admitting the fluid eccentrically, and causing it to rotate rapidly in the chamber. The outlet consists of a small hole, *s*, drilled in the exact center of the face, *e*, of the chamber, and through this outlet the fluid is driven perpendicularly to the plane of rotation in the chamber, and converted into a very fine spray. For a full description of this nozzle the reader is referred to our report as Entomologist to the Department of Agriculture for the years 1881–'82, p. 162. With ordinary force-pump pressure the discharge-hole of the nozzle is about one-sixteenth of an inch in diameter for misty sprays with particles invisibly small. Rather than use the larger, coarser sprays, which were usually employed in these tests, it is better to use the finest spray. The spray falling upon the extension pipe soon accumulates enough to flow down the pole and wet the hands. To prevent this a wrapping washer of leather or other flange

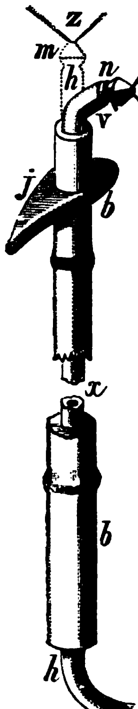

FIG. 4.—*Parts of hose-pole device for spraying trees*: bamboo pole, *b b*; drip washer, *j*; hose, *h x*; side hook, *v*; eddy chamber nozzle, *n m*; spray, *z s*.

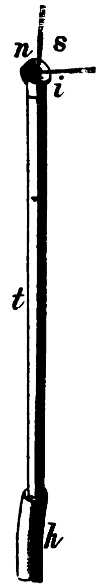

FIG. 5.—*Metallic hand pipe with diagonal nozzle*: hose, *h*; metallic pipe, *t*; diagonal eddy chamber nozzle, *n*; its removable face, *i*; spray, *s*.

may surround the pole proximally from the spray, and the drip will drop off from its margin. Such an arrangement is indicated at *j* in Fig. 4. While one person operates the pump, another, standing in the vehicle or upon the ground, directs the spray by the stiff part of the pipe. Thus the operator can not only spray higher and lower with convenience, but he can, to a great extent, move the spray from place to place without leaving his own position and without moving the vessel of poison with the pump.

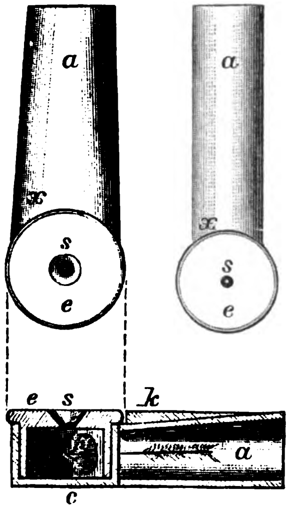

FIG. 6.—*Eddy-chamber nozzle*, natural size; face view and section.

The hose and bamboo combination was conceived of, and used as the lightest, long, stiff tube practicable for these purposes, and it has answered admirably. A similar pole, with a metallic tube in its interior, with a nozzle not producing the very fine mist desired, and lacking the side discharge, &c., was afterward learned of as being used in California. (See Agricultural Department Report, 1881-'82, p. 208.)

By the apparatus used, when everything is prepared, a tree can be sprayed quickly, and a large grove is treated in a short time. It is equally adapted for forestry use in general, and likewise available for poisoning on fruit trees, when not in fruit, while the shorter style of extension-pipe is convenient for underspraying all kinds of low plants.

THE BAG-WORM.

(*Thyridopteryx ephemeræformis* Haw.)

Although this species was not particularly destructive to our shade-trees in 1886, and in numbers greatly inferior to the Fall Web-worm and the Tussock-moth, yet in 1879 it was much more formidable, and at irregular intervals becomes a great pest where not properly dealt with, especially in more southern States. For the past two or three years it has been on the increase in special localities in Washington, and should be carefully looked after.

HABITS AND NATURAL HISTORY.

The Eggs.—During winter time the dependent sacs or bags of this species may be seen hanging on the twigs of almost every kind of tree. If they happen to be on coniferous trees, and they are usually more abundant on these than on deciduous trees, they are not infrequently mistaken for the cones. In reality they are the coverings spun by our worm, and they serve not only as a protection to it, but also to the eggs. Upon cutting open the larger of these bags in winter time they will be found to contain the shell of a chrysalis (technically called the puparium), which is filled with numerous small yellow eggs (Fig. 7 *e*). Each of these is a little over 1 millimeter in length, obovate in form, and surrounded by a delicate, fawn-colored, silky down. In this condition the eggs remain from fall throughout the winter and early spring.

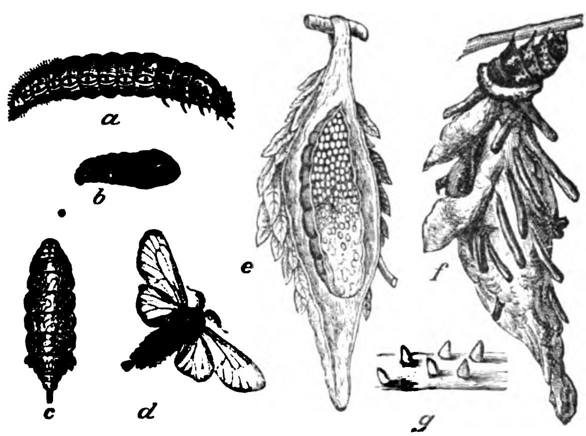

FIG. 7.—*Thyridopteryx ephemeræformis*: *a*, larva; *b*, male chrysalis; *c*, female moth; *d*, male moth; *e*, follicle and puparium cut open to show eggs; *f*, full grown larva with bag; *g*, young larvæ with their conical upright coverings; all natural size.

The Larva and its Bag.—About the middle of May in this latitude the eggs hatch into small but active larvæ, which at once commence to con-

struct a portable case or bag in which to live. The way in which this bag is prepared is curious (Fig. 8). The young larva crawls on a leaf, and

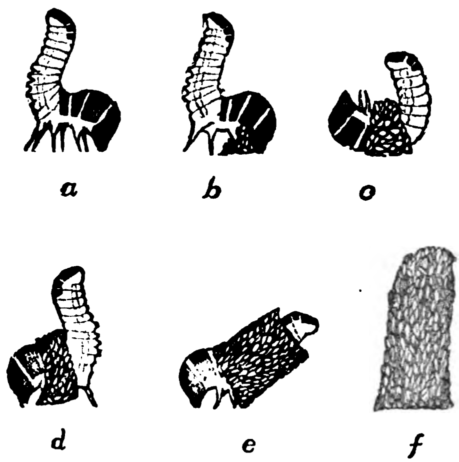

FIG. 8.—*Thyridopteryx ephemeræformis*. How the young larva prepares its bag.

gnawing little bits from the surface, fastens these together with fine silk, produces a narrow, elongate band, which is then fastened at both ends onto the surface of the leaf by silky threads. Having secured itself from falling down by some threads, it now straddles this band and, bending its head downward (Fig. 8 *b*), makes a dive under it, turns a complete somersault and lies on its back, held down by the band (Fig. 8 *c*). By a quick turning movement the larva regains its feet, the band now extending across its neck (Fig. 8 *d*). It then adds to the band at each end until the two ends meet, and they are then fastened together so as to form a kind of narrow collar which encircles the neck of the worm. Far from resting, it now busies itself by adding row after row to the anterior or lower end of the collar, which thus rapidly grows in girth and is pushed further and further over the maker (Fig. 8 *e*). The inside of this bag is now carefully lined with an additional layer of silk, and the larva now marches off, carrying the bag in an upright position (Fig. 7 *g* and Fig. 8 *f*). When in motion or when feeding, the head and thoracic segments protrude from the lower end of the bag, the rest of the body being bent upward and held in this position by the bag. As the worms grow they continue to increase the bags from the lower end and they gradually begin to use larger pieces of leaves, or bits of twigs or any other small objects for ornamenting the outside. Thus the bags will differ according to the different kind of tree or shrub upon which the larva happens to feed; those found on coniferous trees being ornamented with the filiform pine leaves, usually arranged lengthwise on the bag, while those on the various deciduous trees are more or less densely and irregularly covered with bits of leaves interspersed with

pieces of twigs. When kept in captivity the worms are very fond of using bits of cork, straw, or paper, if such are offered to them. When the bags, with the growth of the larva, get large and heavy, they are no longer carried, but allowed to hang down (Fig. 7 *f*). The worms undergo four molts, and at each of these periods they close up the mouth of their bags to remain within until they have cast their skin and recovered from this effort. The old skin, as well as the excrement, is pushed out through a passage which is kept open by the worms at the extremity of the bag.

The young larva is of a nearly uniform brown color, but when more full-grown that portion of the body which is covered by the bag is soft, of light-brown color and reddish on the sides, while the head and thoracic joints are horny and mottled with dark-brown and white (Fig. 7 *a*). The numerous hooks with which the small, fleshy prolegs on the middle and posterior part of the body are furnished, enable the worm to firmly cling to the silken lining of the bag, so that it can with difficulty be pulled out.

The bag of the full-grown worm (Fig. 7 *f*) is elongate-oval in shape, its outlines being more or less irregular on account of the irregularities in the ornamentation above described. The silk itself is extremely tough and with difficulty pulled asunder.

The larvæ are poor travelers during growth, and though, when in great numbers, they must often wander from one branch to another, they rarely leave the tree upon which they were born unless compelled to do so by hunger through the defoliation of the tree. When full-grown, however, they develop a greater activity, especially when very numerous, and, letting themselves down by a fine silken thread, travel fast enough across sidewalks or streets and often for a considerable distance until they reach another tree, which they ascend. This migratory desire is instinctive; for should the worms remain on the same tree they would become so numerous as to necessarily perish for want of food.

Pupation.—The bags of the worms which are to produce male moths attain rather more than an inch in length, while those which produce females attain nearly double this size. When ready to transform, the larva firmly secures the anterior end of the bags to a twig or branch, and instinct leads it to reject for this purpose any deciduous leaf or leaf-stem with which it would be blown down by the winds. The inside of the bag is then strengthened with an additional lining of silk, and the change to chrysalis is made with their heads always downward. The chrysalis is of a dark-brown color, that of the male (Fig. 7 *b*) being only half the size of that of the female (Fig. 7 *e* and Fig. 9 *a*).

The Imago or perfect Insect.—After a lapse of about three weeks from pupation a still greater difference between the two sexes becomes apparent. The male chrysalis works its way to the lower end of the bag and half way out of the opening at the extremity. Then its skin bursts

and the imago appears as a winged moth with a black, hairy body and glassy wings (Fig. 7 *d*). It is swift of flight, and, owing to its small size and transparent wings, is rarely observed in nature. The life-duration of this sex is also very short. The female imago is naked (save a ring of pubescence near the end of the body of yellowish-white color), and entirely destitute of legs and wings (Fig. 7 *c*, and Fig. 9 *b*). She pushes her way partly out of the chrysalis, her head reaching to the lower end of the bag, where, without leaving the same, she awaits the approach of the male. The manner in which the chrysalis shell is elongated and reaches to the end of the bag is shown in Fig. 9 *a*, and an enlarged side view of the female, showing the details of structure, is shown at *b*, in the same figure. The extensility of the male genitalia, which permits him to reach the female within her bag, is set forth in the accompanying Fig. 10, where the parts are shown at rest, *c* and *d*, and in action, *b*. Fertilization being accomplished, the female works her way back within the chrysalis skin and fills it with eggs, receding as she does so toward the lower end of the bag, where, having completed the work of oviposition, she forces, with a last effort, her shrunken body out of the opening, drops exhausted to the ground, and perishes. When the female has withdrawn the slit at the head of the puparium and the elastic opening of the bag close again, and the eggs thus remain securely protected till they are ready to hatch the ensuing spring.

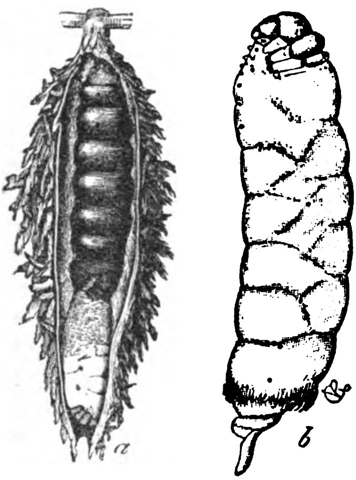

FIG. 9.—*Thyridopteryx ephemeræformis*: *a*, Follicle cut open to show the manner in which the female works from her puparium and reaches the end of the bag, natural size; *b*, female extracted from her case, enlarged.

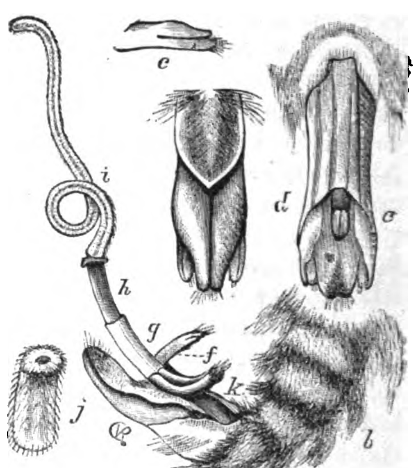

FIG. 10.—*Thyridopteryx ephemeræformis*: *b*. The end of male abdomen from the side, showing genitalia extended; *c*, genitalia in repose ventral view; *d*, do, dorsal view enlarged.

GEOGRAPHICAL DISTRIBUTION.

The Bag-worm occurs most frequently in the more southern portion of the Middle States and in the Southern States, but seems to be absent from the Peninsula of Florida. Within these limits it extends from the Atlantic to Texas, and reaches the less-timbered region west of the Mississippi. Northward,

it is occasionally found in New York, and even Massachusetts, but so rarely and locally restricted that neither Dr. Harris nor Dr. Fitch mention it in their publications on economic entomology. Wherever it occurs it prefers the gardens and parks within or near the cities, being much less abundant in the woods remote from cities, and this dependence upon the vicinity of human civilization is more marked in this species than in any of the others here treated of.

FOOD PLANTS.

The Bag-worm is known to feed on a large number of trees and shrubs, but has a predilection for certain kinds of coniferous trees, notably the Red Cedar and Arbor Vitæ, and as these evergreens are much less able to stand the loss of their foliage than the deciduous trees, the worms are much more dangerous to the former than to the latter. The Hard Maples are, as a rule, avoided by the worms, and it is also quite noticeable that they are not particularly fond of oak leaves and those of the Paulonias. The Ailanthus trees are also generally exempt from their attacks, either on account of the unpleasant taste of the leaves, or perhaps on account of the compound nature of the leaves, the worms fastening their bags to the leaf stems which fall to the ground in Fall. With these exceptions,* the worms, when sufficiently numerous, do great damage to most other kinds of trees used in our cities as shade and park trees.

ENEMIES.

The Bag-worm is so well protected in all its stages that no insectivorous bird nor predaceous insect is known to attack it. In spite of

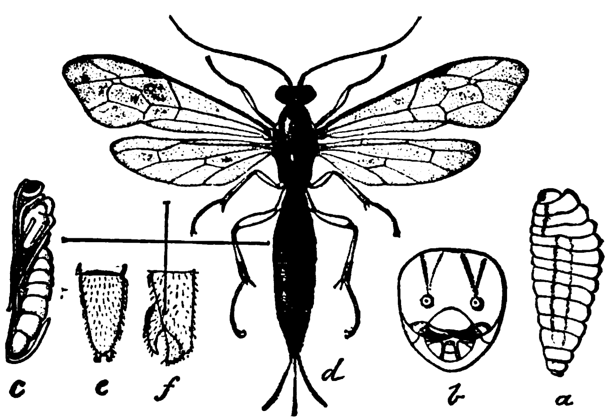

FIG. 11.—*Pimpla conquisitor:* *a*, larva; *b*, head of do. from front; *c*, pupa; *d*, adult female (hair line indicating natural size); *e*, end of male abdomen from above; *f*, same from the side—all enlarged.

the absence of predaceous enemies, the Bag-worm suffers from the attacks of at least six true parasites, while two others, which may be

* The China trees of our Southern cities are entirely exempt from the worms.

primary but are probably secondary. are reared from the bags. Three of these are Ichneumonids, viz: (1) *Pimpla conquisitor* Say (Fig. 11); (2) *Pimpla inquisitor* Say, and (3) *Hemiteles thyridopterigis* Riley (Fig. 12).

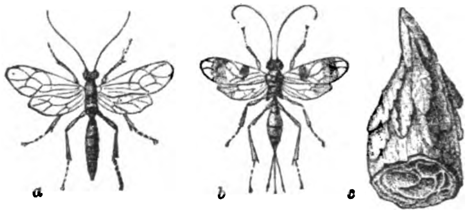

FIG. 12.—*Hemiteles thyridopterigis*: *a*, male; *b*, female; *c*, sack of bag-worm cut open, showing cocoons of parasite, natural size.

Of these, the last-named is most abundantly bred, and we have always considered it as the most important parasite of the Bag-worm. The past season, however, we have ascertained that three species of the genus *Hemiteles*, viz: *H. utilis*, and two undescribed species, are unquestionably secondary parasites, and this renders it quite likely that *H. thyridopterigis* may also be secondary, or, in other words, a parasite of one of the true parasites of the Bag-worm. It is a question, however, which only the most careful study, with abundant material, can decide, as the law of unity of habit in the same genus finds many exceptions in insect life. The other parasites are as follows: (4) *Chalcis ovata* Say. This parasite is a very general feeder on Lepidopterous larvæ, and we have bred it from seven widely different species. (5) *Spilochalcis mariæ* (Riley). This species, while parasitic on Thyridopteryx, is more partial to the large silk-spinning caterpillars, as we have reared it from the cocoons of all of our large native Silk-worms. (6) *Pteromalus* sp. This undescribed Chalcid is found very abundantly in the Bags, but may be a secondary parasite. (7) *Dinocarsis thyridopterygis* Ashmead. This parasite was bred from the Bags in Florida by Mr. William H. Ashmead, who believes it to be parasitic on the eggs. (8) *Tachina* sp. We have bred a large bluish Tachinid from the Bags. Its eggs are commonly attached to the Bags externally, near the neck, and the young larvæ, on hatching, work their way into the case. They frequently fail, however, to reach the Bag-worm.

THE WHITE-MARKED TUSSOCK-MOTH.

(*Orgyia leucostigma* Smith & Abbot.)

HABITS AND NATURAL HISTORY.

The Eggs.—During the month of June, and more especially late in fall and throughout the winter, glistening white objects may be seen on the trunks and the larger branches of trees, or in the corners of the fences near by, or on bunches of dead leaves hanging on the tree (see Fig. 13 *a*). Upon examination these masses will be found to be glued onto a cocoon of dirty gray color, and to consist of numerous perfectly round, cream-white eggs, which are partly covered by a glistening white froth

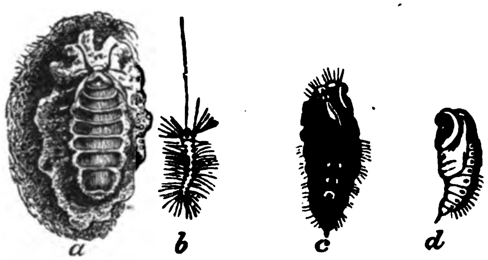

Fig. 13.—*Orgyia leucostigma*: *a*, female on cocoon; *b*, larva; *c*, female pupa; *d*, male pupa.

or spittle-like matter. In one of these egg-masses which we received from Kansas we have counted as many as 786 eggs, while from another mass we obtained upward of 400 young caterpillars.

Development and Characters of the Larva.—In the latitude of Saint Louis, Mo., and Washington the eggs begin to hatch about the middle of May, and the newly-born caterpillar, not quite 3 millimeters in length, is of dull whitish-gray color, with the under side paler, the upper side being covered with rather long hairs and tufts of a dark-brown color. In two days from hatching small orange spots begin to appear along

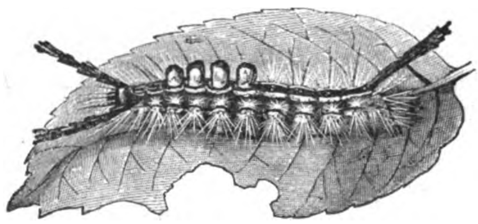

Fig. 14.—*Orgyia leucostigma*: female caterpillar.

the back, and on the seventh day the first molt takes place, to be followed at intervals of six days each by the second and third molts. The changes that take place during this time in the appearance of the caterpillar are remarkable, and after the third molt it is a beautiful ob-

ject and of striking appearance (Fig. 14). The head and two little elevated spots situated on joints 9 and 10, are bright vermilion-red; the back is velvety black with two bright yellow subdorsal lines, and another yellow line each side along the lower sides. The whole body is thinly clothed with long pale yellow hairs, originating from small wart-like elevations. Four cream-colored or white dense brushes of hair are in a row on the middle of the fourth, fifth, sixth, and seventh dorsal joints, while from each side of the head arises a long plume-like tuft of black hair projecting forward and outward. A similar plume projects upwards from the last dorsal joint. The hairs composing these plumes are coarse, barbed, knobbed, and arranged in sets of unequal length, thus giving the plumes a turbinate appearance.

Habits of the Larva.—The young caterpillars scatter all over the tree soon after hatching. When disturbed they make free use of a fine silken thread which they spin, and by which they let themselves down. The full-grown larvæ are often seen to change quarters and travel from one branch to another, or from one tree to another. Their rather quiet way of moving contrasts strongly with the nervous movements of the Fall Web-worm.

A new Form of Orgyia Attack.—In the first edition we omitted to make mention of a most interesting account of a new form of Orgyia attack which had just been published at that time by Mr. Lintner in his second report as State entomologist of New York. We can not now do bett r than to insert his account of this peculiar injury in his own words. It is an interesting instance of a new habit having been locally acquired, and, so far as we have been able to ascertain, it has been observed nowhere else—

"In the summer of 1883, contemporaneously with the first appearance of the Orgyia attack upon the foliage, between the 10th and the 15th of June, the sidewalks, streets, and public parks in Albany, wherever the white elm (*Ulmus Americanus*) was growing, were observed to be sprinkled with newly-fallen leaves. They continued to drop in increasing number until toward the close of the month, when, in many places where they had been permitted to lie undisturbed, they completely covered the walks or ground.

"Upon taking some of them up for examination, they were found to be attached to the tips of the twigs and to comprise nearly all of the new growth of the season. The pieces were from 2 to 3 inches in length, each bearing from four to ten fresh uninjured leaves. It was evident that they were not being broken off by unusually high winds, for even in the absence of winds each day continued to add to their number and to increase the abundance of the fall.

"Making critical observation for the discovery, if possible, of the cause of so unusual a phenomenon, it was noticed that from above the point at which the tip had been broken the bark was entirely removed for an extent averaging one-tenth of an inch. The manner of its removal showed it to have been eaten by an insect. The suggestion was made to me that it was the work of some small insect of similar habits to those of the twig girdler, *Oncideres cingulatus* (Say), but the closest examination failed to show either scar or egg within the tip.

"From the character of the injury, together with the abundant presence of the caterpillar upon the trees at the time, and of no other observed depredator, I believed that it was the work of the Orgyia. If so, it was of especial interest, as showing a new habit developed, for this form of attack had never been recorded of the insect. To verify the belief, after ascending some trees and examining branches within reach from windows, I went upon a house-top, where the limbs of a large elm projecting over the roof gave an excellent opportunity for examination. The larvæ were abundant upon the tree; the flat roof was strewn over and heaped in corners with the broken-off tips; very many girdled tips still held their place on the tree, and after careful search Orgyia larvæ were discovered in the act of eating the bark at the girdled points. From later observations it appeared that the girdling had at this time nearly ceased.

"The following explanation of the cause of the falling of the girdled tips seems a rational one. Upon the eating away of the bark by the Orgyia caterpillar, the wood rapidly dried from its exposure to the air and arrest of circulation, and soon became so brittle that from a moderate swaying of the branches the weight of a half dozen or more of large succulent leaves would occasion the breaking off of the slender twig—often not exceeding in its dried state the diameter of an ordinary pin.

"For the occurrence at this time of this novel form of Orgyia attack, I can only offer the following as a plausible explanation: The spring had been remarkably cold, and as a consequence the development of the foliage had been delayed to quite beyond the ordinary time. The sudden advent of warm weather caused a corresponding sudden start in vegetation, followed by a vigorous growth, and the young tips of the elm would, as the result, be unusually tender. The particular feeding ground of many of the lepidopterous larvæ is known to be selected only after repeated tastings and rejections of such portions of their food-plant as they traverse and a final acceptance of that most agreeable to them. By a process like this the Orgyia may have made the discovery that just at the commencement of the new growth, as the result of the seasonal conditions above mentioned, there was concentrated in the tender bark nutriment far more acceptable to it than that offered in the leaves, upon which alone it had hitherto been accustomed to feed. As the bark hardened with the advancing season it would cease to be desirable for food. * * *

"On my return to Albany for a few days, on the 21st of July, most of the tips then falling and many of those upon the ground presented a new feature. The breaking, instead of being at the base of the girdling, just above the commencement of the new growth, was, in these, at the preceding node, covering the growth of the former year. As a rule, the twigs showed a greater diameter at their decorticated portion, compared with those of the earlier fall, and the leaves attached to them had been all more or less eaten by the Orgyia. Their greater strength had permitted them to remain longer upon the tree, and until the death of the preceding internode, which soon followed the arrest of the circulation—its starvation ensuing—it being unprovided with leaves through which a circulation could still be maintained. When dead, a slight movement of the branch by the wind, or even the weight of the terminal leaves, would be sufficient to disconnect it at its lower and weaker node. In a few instances, where the girdling had been at a little distance above the node marking the commencement of the present year's growth, the separation had been at this point, while others separated in this

manner, instead of the narrow girdling band, had had the bark irregularly removed for the extent of an inch or more. All these later falling twigs showed the interval that had elapsed between the injury and the fall, in that the roughened edges of the bark left by the gnawing had healed over with the peculiar roughened and rounded enlargement following the deposit of the reparative material under such conditions. Some of the twigs gathered gave excellent illustration of the ascent of the sap through the outer wood, and its return, after assimilation in the leaves, through the inner bark. In one instance, where the leaves were unusually large, the descending sap, arrested at the girdled point, had built up structure in the tip until its diameter was more than double that of the starved internode below, while the immediate point of the arrest was quite enlarged from the material there deposited.

"This peculiar attack did not extend to the other principal food-plants of the Orgyia, as the horse-chestnut, maple, apple and plum, nor would it be expected to occur in connection with growth and structure so different from that of the elm."

Pupation.—Six days after the third molt a portion of the larvæ spin up; all these produce male moths. The female caterpillars, which up to this time have been undistinguishable from the male caterpillars, undergo a fourth (and, as it appears from more recent experience, in some instances even a fifth) molt and acquire twice the size of the male caterpillar. This last, when full grown, measures about 20 millimeters in length. The cocoon spun by the male caterpillar is of whitish or yellowish color and sufficiently thin to show the insect within. It consists of two layers, the hairs of the tufts and brushes of the caterpillar being interwoven with the outer layer. The female cocoon is correspondingly larger, of gray color, and much more solid and denser than the male cocoon. The male chrysalis (Fig. 13 *d*), which is soon formed within the cocoon, is of brownish color, sometimes whitish on the ventral side, and covered on the back and sides with fine white hairs. The female chrysalis (Fig. 13*c*) is much larger than the male, and otherwise differs, especially in lacking the wing-sheaths and in having on the three first segments after the head transverse, flattened protuberances composed of scales, which are much less visible in the male. The duration of the pupa state is less than a fortnight.

The Imago.—The male (Fig. 15) is a winged moth with feathery antennæ and very hairy fore legs. The general color is ashy-gray, the front wings being crossed by undulated bands of darker shade, with two black markings on the outer edge near the tip and a white spot on the inner edge also near the tip. He may frequently be seen sitting on the trunks of trees or on the shady side of houses, etc., as he rests during the day, and flies only after dusk, often being attracted by light. The female (Fig. 13*a*) is totally different from the male in appearance and resembles a hairy worm rather than a moth, since she possesses the merest rudiments of wings. She is of a pale gray color, the antennæ being short and not feathered, the legs

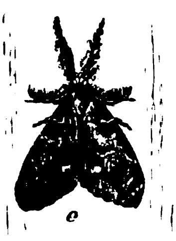

FIG. 15.—*Orgyia leucostigma*: male.

rather slender and not covered with long hairs. She has consequently no power of flight, and is barely able to walk. After working her way out of the chrysalis and cocoon she takes her place on the outside of the latter and patiently awaits the approach of the male. Here she also deposits and protects her eggs in the manner already mentioned, after which she drops exhausted to the ground and perishes. The white mass covering the eggs is at first viscous, but soon dries, becoming brittle, and is impervious to water.

Hibernation.—The species hibernates normally in the egg state, but occasionally a living chrysalis may be found in winter time. On January 30, 1874, we received from Mr. Hunter Nicholson, from Knoxville, Tenn., a newly-hatched female, and this had, no doubt, prematurely issued from a hibernating chrysalis. This is, however, quite exceptional, and the different climatic conditions to which the species is subjected in its wide distribution do not seem to alter the normal mode of hibernation.

Number of Annual Generations.—In the latitude of Washington the species is two-brooded, the imagos of the first generation appearing in the first part of June, those of the second generation in September and October. On several occasions we have found, however, that a portion of the caterpillars from one and the same batch of eggs would be feeding while the rest had already transformed to imagos. The result of this retardation and irregularity in development is that caterpillars may be found continuously throughout the season from June till October, and that there is, consequently, no distinct dividing line between the two generations. In the more northern States the species is single-brooded, the caterpillars appearing in the months of July and August.

FOOD PLANTS.

This caterpillar has most often been referred to by writers on economic entomology as injurious to fruit trees, such as Plum, Pear, and more particularly the Apple; but it also attacks a great many shade trees, and has been for many years particularly injurious to the elms and the soft or silver maples in some of our larger New England cities. It has also a predilection for old or large trees.

NATURAL ENEMIES AND PARASITES.

The fact that the caterpillar makes no effort to conceal itself shows that it enjoys immunity from enemies, and notably from birds. In fact, the American Yellow-billed Cuckoo, the Baltimore Oriole, and the Robin are the only birds which have been observed to feed upon the larvæ. Predaceous insects are also not particularly fond of this hairy caterpillar, the well known Wheel-bug (*Prionidus cristatus*, see Fig. 16) and a few other Soldier-bugs being the only species which occasionally suck its

juices. Nocturnal birds, and especially bats, will, no doubt, devour many of the male moths flying about after dusk, but the destruction of a portion of the males has no appreciable influence on the decrease of

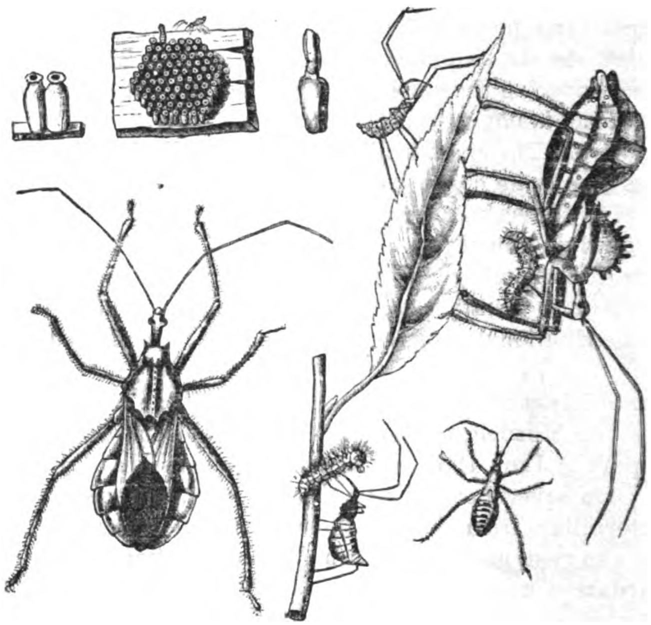

Fig. 16.—*Prionidus cristatus*: eggs, larvæ, and full-grown specimens.

the worms of the next generation. The egg-masses appear to be effectually protected by the froth-like covering, as neither bird nor predaceous insect has been observed to destroy them.

While the list of enemies that devour the species is thus small, that of the parasites is fortunately quite large, and it is due to their influence that the caterpillars are not permanently injurious. There are several true parasites of this insect. Fitch described one species which he bred in considerable numbers from the larva, as *Trichogramma? orgyiæ*, but a perusal of his account indicates plainly that this parasite is an *Eulophus*. He also described a closely-related insect as *Trichogramma? fraterna* and gave it as a very probable parasite of *Orgyia*. There is, however, not the slightest evidence of such parasitism, and this insect must in future be excluded from the list of parasites of the Orgyia larvæ. We have reared from this insect *Pimpla inquisitór*, and an undetermined Tachinid fly, and have had from the larva the cocoons of a Microgaster which has not been reared to the imago. We have also bred a true egg-parasite of the genus *Telenomus*, two distinct species of the genus *Pteromalus* from the larvæ, and Mr. Lintner has sent us a specimen of a species of *Tetrastichus* which is probably parasitic upon one of the *Pteromali*. Further characterization of these species we defer to another occasion.

GEOGRAPHICAL DISTRIBUTION.

This species is widely distributed in North America east of the more timberless regions of the West, extending northward as far as Canada and southward well into the Southern States. It is most abundant in the Middle and New England States, but it is a noticeable fact that wherever it occurs it is more frequent within our cities, or in gardens and orchards near by, than in the woods remote from human habitation.

THE FALL WEB-WORM.

(*Hyphantria cunea*, Drury.)

"This insect has from time to time attracted general attention by its great injury to both fruit and shade trees. Many authors have written about it, and consequently it has received quite a number of different names. The popular name 'Fall Web-worm,' first given to it by Harris, in his 'Insects injurious to Vegetation,' is sufficiently appropriate as indicating the season when the webs are most numerous. The term is, however, most expressive for the New England and other Northern States, where the insect is single-brooded, appearing there during August and September, while in more southern regions it is double-brooded. In our Third Missouri Report we have first called attention to its double-broodedness at Saint Louis, and we find that it is invariably two-brooded at Baltimore and Washington. Except in seasons of extreme increase, however, the first brood does no wide-spread damage, while the fall brood nearly always attracts attention.

"We have decided to call attention to this insect somewhat in detail in this report, because of its exceptional prevalence and injury in the Atlantic States during the year 1886, and because it became a public nuisance in the city of Washington, and the District Commissioners have formally requested information from us on the subject."

NATURAL HISTORY.

Limitation of Broods.—"At Washington we may say in general that the first brood appears soon after the leaves have fully developed, and numerous webs can be found about the first of June, while the second brood appears from the middle of July on through August and September. In Massachusects and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

"The species invariably hibernates in the chrysalis state within its cocoon, and the issuing of the first brood of moths is, as a consequence, tolerably regular as to time, *i. e.*, they will be found issuing and flying slowly about during the evening, and more particularly at night, during the whole month of May, the bulk of them early or late in the month, according as the season may be early or late. They couple and oviposit

very soon after issuing, and in ordinary seasons we may safely count on the bulk of the eggs being laid by the end of May. During the month of June the moths become scarcer and the bulk of them have perished by the middle of that month, while the webs of the caterpillars become more and more conspicuous. The second brood of moths begins to appear in July, and its occurrence extends over a longer period than is the case with the first or spring brood. The second brood of caterpillars may be found from the end of July to the end of September, hatching most extensively, however, about the first of August.

"In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

"The following general remarks upon the different stages refer to Washington and localities where the same conditions hold:

The Eggs (Fig. 17, *b*).—"The female moth deposits her eggs in a cluster on a leaf, sometimes upon the upper and sometimes on the lower side, usually near the end of a branch. Each cluster consists of a great many eggs, which are deposited close together and in regular rows, if the surface of the leaf permits it. In three instances those deposited by a single female were counted. The result was 394, 427, and 502, or on an average 441 eggs. But in addition to such large clusters, each female will deposit eggs in smaller and less regular patches, so that at least 500 eggs may be considered as the real number produced by a single individual. The egg, measuring 0.4 millimeters, is of a bright golden-yellow color, quite globular, and ornamented by numerous regular pits, which give it under a magnifying lens the appearance of a beautiful golden thimble. As the eggs approach the time of hatching this color disappears and gives place to a dull leaden hue.

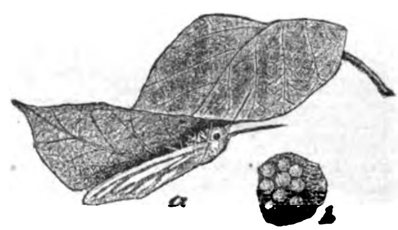

FIG. 17.—*Hyphantria cunea*: *a*, moth in position on leaf laying eggs, side view; *b*, eggs enlarged.

"The interval between the time of depositing and hatching of the eggs for the first brood varies considerably, and the latter may be greatly retarded by inclement weather. Usually, however, not more than ten days are consumed in maturing the embryo within. The eggs of the summer brood seldom require more than one week to hatch.

"Without check the offspring of one female moth might in a single season (assuming one-half of her progeny to be female and barring all checks) number 125,000 caterpillars in early fall—enough to ruin the shade-trees of many a fine street.

The Larva (Fig. 18, *a*, *b*, and *c*).—"The caterpillars just born are pale yellow, with two rows of black marks along the body, a black head, and with quite sparse hairs. When full grown they generally appear pale yellowish or greenish, with a broad dusky stripe along the back and a yellow stripe along the sides; they are covered with whitish hairs, which spring from black and orange-yellow warts. The caterpillar is,

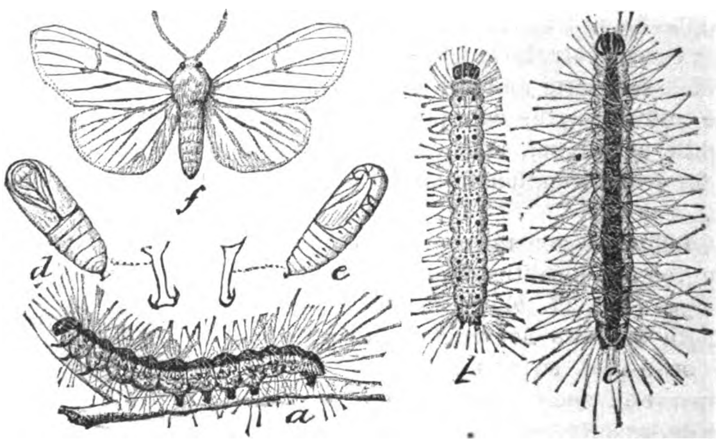

FIG. 18.—*Hyphantria cunea:* *a*, dark larva, seen from side; *b*, light larva from above; *c*, dark larva from above; *d*, pupa from below; *e*, pupa from side; *f*, moth.

however, very variable both as to depth of coloring and as to markings. Close observations have failed to show that different food produces changes in the coloration; in fact, nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker with browner hairs than the spring generation.

"As soon as the young caterpillars hatch they immediately go to work to spin a small silken web for themselves, which by their united efforts soon grows large enough to be noticed upon the trees. Under this protecting shelter they feed in company, at first devouring only the green upper portions of the leaf and leaving the veins and lower skin unmolested. As they increase in size they enlarge their web by connecting it with the adjoining leaves and twigs; thus as they gradually work downwards their web becomes quite bulky, and, as it is filled with brown and skeletonized leaves and other discolored matter, as well as with their old skins, it becomes quite an unpleasant feature in our public thoroughfares and parks. The caterpillars always feed underneath these webs; but as soon as they approach maturity, which requires about one month, they commence to scatter about, searching for suitable places in which to spin their cocoons. If very numerous upon the same tree the food-supply gives out, and they are forced by hunger to leave their sheltering homes before the usual time.

"When the young caterpillars are forced to leave their webs they do not drop suddenly to the ground, but suspend themselves by a fine silken thread, by means of which they easily recover the tree. Grown caterpillars, which measure 1.11 inches in length, do not spin such a thread. Both old and young ones drop themselves to the ground without spinning when disturbed or sorely pressed by hunger.

Pupa and Cocoon.—"Favorite recesses selected for pupation are the crevices in bark and similar shelters above ground; in some cases even the empty cocoons of other moths.* The angles of tree-boxes, the rubbish collected around the base of trees and other like shelter are employed for this purpose, while the second brood prefer to bury themselves just under the surface of the ground, provided that the earth be soft enough for that purpose. The cocoon itself is thin and almost transparent, and is composed of a slight web of silk intermixed with a few hairs, or mixed with sand if made in the soil.

"The pupa (Fig. 18, *d* and *e*) is of a very dark-brown color, smooth and polished, and faintly punctate; it is characterized by a swelling or bulging about the middle. It is 0.60 inch long and 0.23 inch broad in the middle of its body, or where it bulges a little all round.

The Moth (Fig. 18, *b*).—"The moths vary greatly, both in size and coloration. They have, in consequence of such variation, received

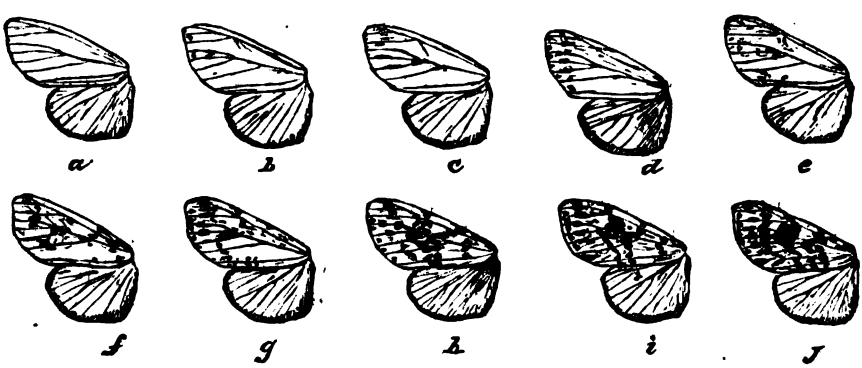

FIG. 19.—*Hyphantria cunea: a–j*, wings of a series of moths, showing the variations from the pure white form to one profusely dotted with black and brown.

many names, such as *cunea* Drury, *textor* Harr., *punctata* Fitch, *punctatissima* Smith (Fig. 19). But there is no doubt, as proven from frequent breeding of specimens, that all these names apply to the very same insect, or at most to slight varieties, and that Drury's name *cunea*, having priority, must be used for the species.

"The most frequent form observed in the vicinity of Washington is white, with a very slight fulvous shade; it has immaculate wings,

* We have known the substantial cocoon of *Cerura* to be used for this purpose.

tawny-yellow front thighs, and blackish feet; in some specimens the tawny thighs have a large black spot, while the shanks on the upper surface are rufous. In many all the thighs are tawny yellow, while in others they have scarcely any color. Some specimens (often reared from the same lot of larvæ) have two tolerably distinct spots on each front wing—one at base of fork on the costal nerve and one just within the second furcation of the median nerve. Other specimens, again, have their wings spotted all over, and approach the form *punctatissima*, described as the "Many-spotted Ermine-moth" of the Southern States. The wings of the moths expand from 1¼ inches to 1⅜ inches. The male moth, which is usually a little smaller, has its antennæ doubly feathered beneath, and those of the female possess instead two rows of minute teeth.

"The pupa state lasts from six to eight days for the summer brood, while the hibernating brood, however, requires as many months, according to the latitude in which they occur.

INJURY DONE IN 1886.

"During the past year the city of Washington, as well as its vicinity, was entirely overrun by the caterpillars. With the exception of trees and plants the foliage of which was not agreeable to the taste of this insect, all vegetation suffered greatly. The appended list of trees, shrubs, and other plants shows that comparatively few kinds escaped entirely. The fine rows of shade trees which grace all the streets and avenues appeared leafless, and covered with throngs of the hairy worms. Excepting on the very tall trees, in which the highest branches showed a few leaves too high for the caterpillars to reach, not a vestige of foliage could be seen. The trees were not alone bare, but were still more disfigured by old and new webs made by the caterpillars, in which bits of leaves and leaf-stems, as well as the dried frass, had collected, producing a very unpleasant sight. The pavements were also constantly covered with this unsightly frass, and the empty skins of the various molts the caterpillars had to undergo were drifted about with every wind, and collected in masses in corners and tree-boxes. The parks fared a little better. Because of the great variety of trees planted there some escaped entirely, while others showed the effect of the united efforts of so many hungry caterpillars only in a more or less severe degree. The grassy spots surrounding the different groups of trees had also a protective influence, since the caterpillars do not like to travel over grass, except when prompted by a too ravenous hunger. The rapid increase of this insect is materially assisted by the peculiar method of selecting shade trees for the city. Each street has, in many cases, but one kind of shade tree; rows of them extend for miles, and the trees are planted so close together that their branches almost interlace. Thus there is no obstacle at all to the rapid increase and distribution of

the caterpillars. If different kinds of trees had been planted, so as to alternate, less trouble might be experienced. Plate I shows a view of Fourteenth street, taken late in September, which illustrates this point; the poplars on the west side being completely defoliated as far as the eye can reach, while the maples on the east are almost untouched.

"As long as the caterpillars were young, and still small, the different communities remained under cover of their webs, and only offended the eye. But as soon as they reached maturity, and commenced to scatter—prompted by the desire to find suitable places to spin their cocoons and transform to pupæ—matters became more unpleasant, and complaints were heard from all those who had to pass such infested trees. In many localities no one could walk without stepping upon caterpillars; they dropped upon every one and everything; they entered flower and vegetable gardens, porches and verandas, and the house itself, and became, in fact, a general nuisance.

"The chief damage done to vegetation was confined to the city itself, although the caterpillars extended some distance into the surrounding country. There, however, they were more local, and almost entirely confined to certain trees, and mainly so to the White Poplar and the Cottonwood. Along the Baltimore and Potomac Railroad tracks these trees were defoliated as far as five miles from the Capitol. In Georgetown the caterpillars were equally noxious, but in the adjoining forests but very few webs could be seen.

"The proportionate injury to any given species of tree is to some extent a matter of chance, and in some respects a year of great injury, as 1886, is not a good year to study the preferences of a species, because when hard pressed for food the caterpillars will feed upon almost any plant, though it is questionable whether they can mature and transform on those which they take to only under the influence of such absolute necessity. Again, the preference shown for particular trees is more the result of the preference of the parent moth than of its progeny in a case of so general a feeder as the Fall Web-worm. We had a very good illustration of this in Atlantic City last autumn. The caterpillars were exceedingly abundant during autumn along this portion of the Atlantic coast, especially on the trees above named. We studied particularly their ways upon one tree that was totally defoliated by September 11. The bulk of the caterpillars were then just through their last molt, though others were of all ages illustrating different hatchings. There was an instinctive migration of these larvæ of all sizes, and the strength of their food habits once acquired from birth upon a particular tree was well illustrated. At first the worms passed over various adjacent plants, like honeysuckles, roses, etc., the leaves of which they freely devour if

PLATE I.—TREES DEFOLIATED BY THE WEB-WORM.

hatched upon them, but as the migrating swarm became pressed with hunger they finally fell upon these, and even upon plants like the Peach, and Ailanthus, which ordinarily are passed over. They would pounce upon any food, and a rotten apple placed in their way was soon literally swarming with them and sucked dry.

"In a general way it may be stated that conifers, grapes, and most herbaceous plants are free from their attacks, and it is very doubtful whether the species can mature upon them.

"The list of plants which follows is arranged according to the relative damage to the foliage in the city of Washington. The three first named are most subject to attack, and, in fact, are almost always defoliated.

PROPORTIONATE INJURY TO DIFFERENT PLANTS AND SHADE TREES.

"The damage done in the city of Washington was exceptional, but so was also the general damage throughout the New England States, if not throughout the country. In New England the greater predilection which the species showed for Poplar, Cottonwood, and the ranker growing Willows was everywhere manifest, and so much was this the case that the destruction of the first brood on these trees would have substantially lessened the damage to other trees."

Plants marked 1 have lost from 75 to 100 per cent. of their foliage.
Plants marked 2 have lost from 50 to 75 per cent. of their foliage.
Plants marked 3 have lost from 25 to 50 per cent. of their foliage.
Plants marked 4 have lost from 0 to 25 per cent. of their foliage.
Plants marked with two figures have shown the relative immunity or injury indicated by both, the variation being in individual trees.

1. *Negundo aceroides* Mœnch. (Box Elder.)
1. *Populus alba* L. (European White Poplar.)
1. *Populus monilifera* Aiton. (Cottonwood.)
1–2. *Populus balsamifera* L. (Balsam Poplar.)
1–2. *Populus tremuloides* Mich'x. (American Aspen.)
1–2. *Fraxinus americana* L. (White Ash.)
1–2. *Fraxinus excelsior* L. (European Ash.)
1–2. *Sambucus canadensis* L. (Elder.)
1–2. *Pyrus* species. (Cultivated Pear and Apple.)
1–2. *Prunus avium* and *cerasus* L. (Cherries.)
1–4. *Syringa vulgaris* L. (Lilac.)
1–4. *Ilex* spec. (Holly.)
2. *Platanus occidentalis* L. (Sycamore.)
2. *Salix* species. (Willow.)
2. *Tilia americana* L. (American Linden.)
2. *Tilia europæa* L. (European Linden.)
2. *Populus dilatata* Ait. (Lombardy Poplar.)
2. *Ulmus americana* L. (American White Elm.)
2–3. *Ulmus fulva* Mich. (Slippery Elm.)
2–3. *Prunus armeniaca* L. (Apricot.)
2–3. *Alnus maritima* Muhl. (Alder.)
2–3. *Betula alba*, L. (White Birch.)
2–3. *Viburnum* species. (Haw or Sloe.)
2–3. *Lonicera* species. (Honeysuckles.)
2–3. *Prunus americana* Marsh. (Wild Red Plum.)
2–3. *Celtis occidentalis* L. (Hackberry.)
2–3. *Rosa* species. (Rose.)
2–3. *Gossypium album* Ham. (Cotton.)
2–3. *Cephalanthus occidentalis* L. (Button Bush.)
2–4. *Convolvulus* spec. (Morning Glory.)

2–4. *Acer saccharinum* Wang. (Sugar Maple.)
2–4. *Geranium* species. (Geranium.)
3. *Betula nigra* L. (Red Birch.)
3. *Tecoma radicans* Juss. (Trumpet Creeper.)
3. *Symphoricarpus racemosus.* Mich'x. (Snowberry.)
3. *Larix europæa,* Del. (European Larch.)
2. *Corylus americana,* Walt. (Hazelnut.)
3. *Quercus alba* L. (White Oak.)
3. *Diospyros virginiana* L. (Persimmon.)
3. *Carya* species. (Hickory.)
3. *Juglans* species. (Walnut.)
3. *Wistaria sinensis* Del. (Chinese Wisteria.)
3. *Wistaria frutescens* DC. (Native Wisteria.)
3. *Amelanchier canadensis* T. & G. (Shad-bush.)
3. *Cratægus* species. (Haw.)
3. *Rubus* species. (Blackberry.)
3. *Spiræa* species. (Spiræa.)
3. *Ribes* species. (Currant and Gooseberry.)
3. *Staphylea trifolia* L. (Bladder Nut.)
3–4. *Cydonia vulgaris* Pers. (Quince.)
3–4. *Asimina triloba* Dun. (Papaw.)
3–4. *Berberis canadensis* Pursh. (Barberry.)
3–4. *Catalpa bignonioides* Walt. (Indian bean.)
3–4. *Catalpa speciosa* Ward. (Bignonia.)
3–4. *Euonymus atropurpureus* Jaeg. (Burning Bush.)
3–4. *Cupressus thyoides* L. (White Cedar.)
3–4. *Juniperus virginiana* L. (Red Cedar.)
3–3. *Cornus florida* L. (Flowering Dogwood.)
3–4. *Cornus alternifolia* L. (Alternate-leaved Dogwood.)
3–4. *Carpinus americana* Mich'x. (Hornbeam.)
3–4. *Castanea americana* Mich'x. (American Chestnut.)
3–4. *Castanea pumila* Mich'x. (Chinquapin.)
3–4. *Ostrya virginica* Willd. (Hop Hornbeam.)
3–4. *Quercus coccinea* Wang. (Scarlet Oak.)
3–4. *Quercus phellos* L. (Willow Oak.)
3–4. *Quercus prinus* L. (Chestnut Oak.)
3–4. *Quercus rubra* L. (Red Oak.)
3. 4. *Diospyros kaki* L. (Japan Persimmon.)
3–4. *Buxus sempervirens* L. (Common Box.)
3–4. *Hamamelis virginica* L. (Witch Hazel.)
3–4. *Sassafras officinale* Ness. (Sassafras.)
3–4. *Cercis canadensis* L. (Red Bud.)
3–4. *Hibiscus syriacus* L. (Tree Hibiscus.)
3–4. *Rhamnus alnifolius* L'Her. (Alder-leaved Buckthorn.)
3–4. *Prunus virginiana* L. (Choke Cherry.)
3–4. *Persica vulgaris* Mill. (Peach.)
3–4. *Æsculus hippocastanum* L. (Horse Chestnut.)
3–4. *Paulownia imperialis* Seeb. (Cigar Tree.)
3–4. *Ailanthus glandulosus* Daf. (Tree of Heaven.)
3–4. *Maclura aurantiaca* Nutt. (Osage Orange.)
3–4. *Ampelopsis quinquefolia.* Virginia Creeper.)
3–4. *Clematis* species. (Clematis.)
3–4. *Trifolium* spec. (Clover.)
3–4. *Helianthus* spec. (Sunflower.)
3–4. *Jasminum* spec. (Jesamine.)
3–4. *Ficus carica* L. (Fig.)
4. *Rhus cotinus* L. (Smoke Tree.)
4. *Pinus* spec. (Pine.)
4. *Taxus* spec. (Yew.)
4. *Nyssa multiflora* Wangerh. (Sour Gum.)
4. *Fagus ferruginea* Ait. (Beech.)
4. *Kalmia* spec. (Laurel.)
4. *Rhododendron* spec. (Rhododendron.)
4. *Ricinus communis* L. (Castor-oil Plant.)
4. *Liquidambar styraciflua* L. (Sweet Gum.)
4. *Gleditschia triacanthos* L. (Honey Locust.)
4. *Gymnocladus canadensis,* Lamb. (Kentucky Coffee Tree.)
4. *Robinia pseudacacia* L. (Locust.)
4. *Liriodendron tulipifera* L. (Tulip Tree.)
4. *Magnolia* spec. (Magnolia.)
4. *Chionanthus virginicus* L. (Fringe Tree.)
4. *Ligustrum vulgare* L. (Privet.)

4. *Zanthoxylum americanum* M. (Prickly Ash.)
4. *Acer dasycarpum* Ehrh. (White or Silver Maple.)
4. *Acer rubrum* Wangert. (Red Maple.)
4. *Æsculus flava*, Ait. (Sweet Buckeye.)
4. *Æsculus glabra* Willd. (Ohio Buckeye.)
4. *Morus rubra* L. (Red Mulberry.)

"Trees in the vicinity of the White Poplar and Cottonwood suffered most. Even trees usually not injured, as, for instance, the Sugar Maple, are often badly defoliated when in such contiguity.

"This list contains a number of plants not usually injured by these caterpillars. In some cases the injury was due to the fact that twigs containing the web, with its occupants, had been pruned from the tree and thrown near plants, instead of being at once burned or otherwise destroyed.

"In other cases the injury is due to the peculiar position of the plant injured, *i. e.*, under a tree infested by the caterpillars. These when fully grown commence to scatter, and dropping upon the plants underneath the tree so defoliate it without actually making their home upon it. The great number thus dropping from a large tree will soon defoliate any smaller plant, even if each caterpillar takes but a mouthful by way of trial. Thus Holly, a plant not usually eaten by these insects, soon becomes denuded. Other plants unpalatable or even obnoxious to the caterpillars are sometimes destroyed by the multitudes in their search for more suitable food.

"Hungry caterpillars leaving a denuded tree in search of food wander in a straight line to the next tree, sometimes a distance of 25 feet, showing that they possess some keen sense to guide them. If such a tree offers unsuitable food, they still explore it for a long time before deserting it. In this manner two columns of wandering caterpillars are formed, which frequently move in opposite directions.

PECULIAR EFFECT OF DEFOLIATION UPON SOME PLANTS.

"During the early part of October many trees, mainly apple and pear, which had been entirely denuded of their foliage by the caterpillars, showed renewed activity of growth. Some had a few scattered flowers upon them, others had one or two branches clothed with flowers, while in some few cases the whole tree appeared white. It looked as if the trees were covered with snow, since they lacked the green foliage usually seen with the blossoms in spring. Some few flowers were also observed upon badly defoliated cherry-trees. Even as late as the middle of November, owing perhaps also to the pleasantly warm weather, some few flowers could be observed upon some imported plants belonging to the genus *Spiræa* and upon the Chinese Red-apple. All these plants usually blossom early in spring. The caterpillars having entirely defoliated the trees produced thus an artificial period of rest, or winter, which was followed by unseasonable budding and flowering. Such a

result often follows summer denudation by any insect, and we have referred to some remarkable cases in our previous writings.*

ENEMIES OF THE WEB-WORM OTHER THAN INSECTS.

"The caterpillars have comparatively few enemies belonging to the vertebrate animals. This is not owing to any offensive odor or to any other means of defense, but is entirely due to their hairiness. Chickens, and even the omnivorous ducks, do not eat them; if offered to the former they pick at these morsels, but do not swallow them.

"The English sparrow has, in this case at least, not proven of any assistance whatever. Indeed, as before stated, its introduction and multiplication has greatly favored the increase of the worms.

"The 'pellets' of a Screech-owl (*Scops asio*) found in the vicinity of Baltimore, Md., and examined by Mr. Lugger, consisted apparently almost entirely of the hairs of these caterpillars, proving that this useful bird has done good service.

"Perhaps the statement may be of interest, that this little owl is getting much more common in the vicinity of such cities, in which the English sparrow has become numerous, and that the imported birds will find in this owl as bold an enemy as the Sparrow-hawk is to them in Europe, and even more dangerous, since its attacks are made towards dusk, at a time when the sparrow has retired for the night and is not as wide awake for ways and means to escape.

"If our two cuckoos, the black-billed as well as the yellow-billed species, could be induced to build their nests within the city limits or in our parks, we should gain in them two very useful friends, since they feed upon hairy caterpillars.

"The common toad (*Bufo americana*) has eaten great numbers of these caterpillars, as shown by dissections made by Mr. Lugger, and it should be carefully protected instead of being tormented or killed by boys or even grown people. The toad is always a useful animal and ought to be introduced in all gardens and parks.

"The following species of spiders were observed to eat the caterpillars, viz, *Marpessa undata* Koch and *Attus* (*Phydippus*) *tripunctatus*. Neither species builds a web, but obtains its prey by boldly leaping upon it; they are, in consequence of such habits, frequently called Tiger-spiders. The former was exceedingly common last year, more so than for many previous years, thus plainly indicating that the species did not suffer for lack of food. This species is usually found upon the trunks of trees, and is there well protected by its color, which is like that of the bark. It hides in depressions and cracks of the bark, and, jumping upon the passing game, or, cat-like, approaching it from behind, it thrusts its poisonous fangs into the victim, which soon dies and is sucked dry. The *Attus* has similar habits, but is still more cautious; it usually hides

* See Eighth Report on the Insects of Missouri, p. 121.

under loose bark. Both spiders are wonderfully active, and kill large numbers of caterpillars. Their large flat egg-masses can be found during the winter under dead bark and in cracks. Both species hibernate in silken nests in similar localities."

PREDACEOUS INSECT ENEMIES.

The caterpillars of this moth have quite a number of external enemies, which slay large numbers of them. The well-known Rear-horse (*Mantis carolina*, see Fig. 20) seems to be very fond of the caterpillars.

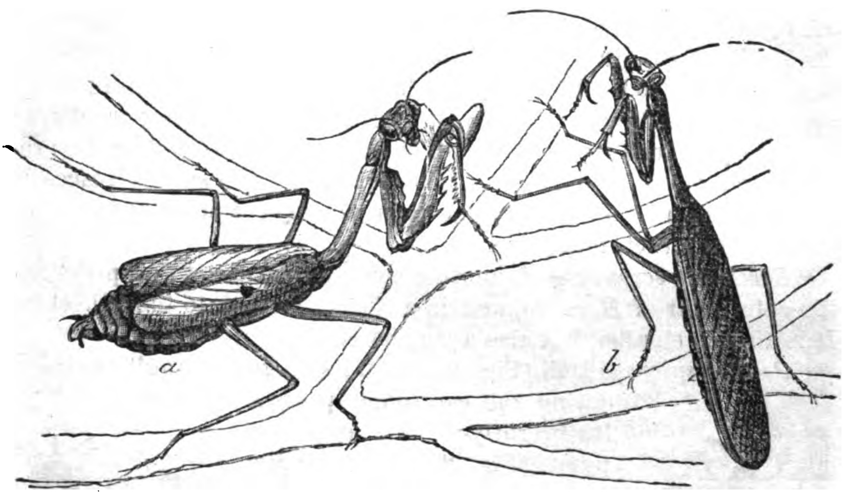

FIG. 20.—*Mantis carolina*: *a*, female; *b*, male.

The so-called Wheel-bug (*Prionidus cristatus*, see Fig. 16) has proved to be one of our best friends in reducing the numbers of the caterpillars. This insect was formerly by no means very common in cities, but of late years it has greatly increased in numbers, and is now a well-known feature in all our public parks and such streets as possess shade-trees. Outside of the city it is rarely met with; nor does it extend much farther north than Washington. It is, like the Mantis, in all its stages a voracious feeder upon insects, slaying alike beneficial and noxious ones. The bright red larvæ and pupæ, also carnivorous, are seen in numbers during the summer; they usually remain together until hunger forces them to scatter. They assist each other in killing larger game, and are to this extent social. The Wheel-bug could be observed almost anywhere last summer, usually motionless, stationed upon the trunk of trees, waiting for the approach of an insect. If one comes near, it quite leisurely inserts its very poisonous beak, and sucks the life-blood of its victim. When this becomes empty it is hoisted up in the air, as if to facilitate the flow of blood, until eventually it is thrown away as a mere shriveled skin. The appetite of the Wheel-bug is remarkable, whenever chances offer to appease it to the fullest extent. Frequently,

however, times go hard with it, and notwithstanding it is very loth to change a position once taken, it is sometimes forced to seek better hunting grounds, and takes to its wings. The Wheel-bug has been observed to remain for days in the same ill-chosen position, for instance upon the walls of a building, waiting patiently for something to turn up. It is slow in all its motions, but withal very observant of everything occurring in its neighborhood, proving without doubt great acuteness of senses. It does not seem to possess any enemies itself, and a glance at its armor will indicate the reason for this unusual exemption.* During warm weather this bug possesses a good deal of very searching curiosity, and a thrust with its beak, filled with poison, is very painful indeed. Boys call it the Blood-sucker, a misnomer, since it does not suck human blood. The eggs are laid during the autumn in various places, but chiefly upon smooth surfaces of the bark of tree-trunks, and frequently in such a position as to be somewhat protected against rain by a projecting branch. The female bug always selects places the color of which is like that of the eggs, so they are not easy to see, notwithstanding their large size.

"*Euschistus servus* Say, is another hemipterous insect that preys upon the caterpillar of *H. cunea*, and in a similar manner to the Wheel-bug. It is a much smaller, but also a very useful insect.

"*Podisus spinosus* Dall. (Fig. 21), in all its stages was quite numerous during the caterpillar plague. Its brightly-colored larvæ and pupæ (Fig. 22) were usually found in small numbers together; but as they grew older they become more solitary in their habits. All stages of this insect frequent the trunk and branches of trees, and are here actively engaged in feeding upon various insects. As soon as one of the more mature larvæ or a pupa has impaled its prey, the smaller ones crowd about to obtain their share. But the lucky captor is by no means willing to divide with the others, and he will frequently project his beak forward, thus elevating the caterpillar into the air away from the others. The habit of carrying their food in such a difficult position has perhaps been acquired simply to prevent others from sharing it. A wonderful strength is necessary to perform such a feat, since the caterpillar is sometimes many times as heavy as the bug itself. The greediness of this bug was well illustrated in the following observations: A pupa of *P. spinosus* had impaled a caterpillar, and was actively engaged in sucking it dry; meanwhile a Wheel-bug utilized a favorable opportunity and impaled the pupa, without forcing the same to let go the

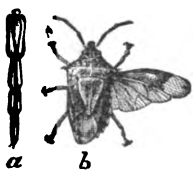

FIG. 21.—*Podisus spinosus*: *a*, enlarged beak; *b*, bug, with right wings expanded.

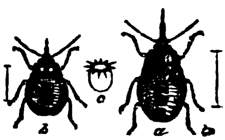

FIG. 22.—*Podisus spinosus*: *a*, pupa; *b*, larva; *c*, egg.

* The eggs of the Wheel-bug are pierced, however, by a little egg-parasite—*Eupelmus reduvii* Howard.

caterpillar. The elasticity of the beak (Fig. 21*a*) of these bugs must be very great; they can bend it in any direction, and yet keep it in sucking operation. The poison contained in the beak must act very rapidly, since caterpillars impaled by it squirm but for a very short time, and then become quiet."

FUNGUS DISEASES OF THE WEB-WORM.

"The first brood of these caterpillars showed in some quite well-defined localities the indications of a fungus disease.* This did not become, however, as general as later in the season, when it prevailed everywhere; yet it could be observed that the contagion had started from certain points. In such localities almost all the caterpillars were diseased and large numbers of the dead were huddled together as in life. But when investigated their bodies were hard and dry, and would readily crumble to pieces when pressed, producing an odor like that of some mushrooms. Only full-grown, or rather caterpillars in their last larval stage, were thus affected. The dry remains had retained the original shape, and, if killed but recently by the fungus, their color as well. Before dying the caterpillars had fastened themselves very securely to trunks, twigs, and leaves of various trees, somewhat like the common house-fly, that dies by a similar disease in large numbers during September in our houses, and produces around itself such a characteristic halo of white spores. Caterpillars infested by the incipient stages of this disease wander about aimlessly and at an irregular speed; often they halt for some time, then squirm about frantically to start again, and frequently in an opposite direction to the one they were going before. If such a diseased caterpillar is confined to a glass jar and observed it is soon seen that a white mealy substance gradually grows out of all the soft spaces between their segments, which eventually covers the whole insect, leaving generally only the black head and tips of hairs visible. Before long many spores are scattered about, forming a circle of white dust around the caterpillar, and, if not arrested by an obstruction in its expulsion, the halo thus formed is quite regular and about 2 inches in diameter. Outdoors this white dust is but seldom observed, because even the slightest draft of air will carry it away and drift it about. Even the white mealy substance adhering to the caterpillar itself is usually swept away, and the victims look very much like healthy caterpillars; but they darken with time and eventually drop to the ground. The magnifying glass, however, still reveals some spores adhering to the hairs, upon the underside, and upon the bark or leaf of the tree in their immediate neighborhood.

"This fungus kills caterpillars even after they have made their cocoons. Nor does the pupa escape. In the latter case the spores form a white crest over every suture of the thoracic segments; the abdominal segments, however, remain free from it. Evidently the caterpillars were nearly full-grown when attacked by the disease, and possessed

* This fungus has been determined by Mr. Roland Thaxter as *Empusa grylli*.

vigor enough to transform into pupæ; later the fungus grew, and, pressing the chitinous portion of the pupa apart, forced its way to the air to fructify.

"Plants not usually eaten by the caterpillars, as well as others not eaten at all, have upon them the largest numbers of caterpillars killed by the fungus, provided that they grow in the vicinity of suitable food-plants. Perhaps unsuitable food, predisposing the caterpillars for any disease, is one of the causes of the innumerable host killed by this fungus.

"The white cocoons of a parasite (*Apanteles hyphantriæ* Riley) of this caterpillar were in some cases observed to be covered with similar spores of a fungus. Opening such cocoons it was seen that the spores were not simply blown upon the silk and there retained, but that they came from the victim within, and had forced their way through the very dense silken covering."

Experiments to obtain percentage of diseased caterpillars.

Experiment I:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) at random in one of our public parks. They were imprisoned in large glass jars and daily supplied with suitable food.

Result, October 18, 1886:

11 apparently healthy pupæ.
3 deformed pupæ.
18 yellow cocoons of *Meteorus hyphantriæ.*
9 dead pupæ, killed by fungus or otherwise.
84 dead caterpillars, killed by fungus or otherwise.

125

In the earth of the jar were found 17 pupæ of Tachina flies, leaving 67 caterpillars and 9 pupæ killed by the fungus, or 61 per cent.

Experiment II:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) from a trunk of a Soft Maple tree (unsuitable food) and treated as above.

Result, October 18, 1886:

8 apparently healthy pupæ.
1 deformed pupa.
7 yellow cocoons of *Meteorus hyphantriæ.*
3 dead pupæ, killed by fungus or otherwise.
104 dead caterpillars, killed by fungus or otherwise.
2 cocoons containing Tachina larvæ.

125

In the earth of the jar were found 28 pupæ of Tachina flies, leaving 76 caterpillars and 3 pupæ killed by fungus, or 63 per cent.

In both experiments it has been assumed that each Tachina fly had killed one caterpillar.

On November 15, 1886, the jars were again investigated, and it was found that a number of the pupæ had been killed by the fungus since October 18, 1886, and that in fact all the remaining ones did not look healthy. The percentage of death by the fungus in the two experiments was thus increased to 63 per cent. in Experiment I and to 67 per cent. in Experiment II.

TRUE PARASITES OF THE WEB-WORM.

Up to the present time no parasites of this insect have ever been recorded. On August 18, 1883, we bred a number of egg-parasites from a batch of eggs found upon a willow leaf at Washington, but unfortunately no description was made of them at the time, and, as they belonged to the soft-bodied genus *Trichogramma*, the specimens have now become so much shriveled and altered that they are unfit for descriptive purposes. We noticed after our return from Europe in September of this year that, at a number of points in New England, the worms were quite commonly attacked by parasites, and careful investigation at Washington by Mr. Lugger showed the presence of no less than five distinct species of primary parasites in addition to the *Trichogramma* just mentioned. These will be considered in some detail. The first was a new egg-parasite which we have named *Telenomus bifidus;* the others were all parasitic on the larvæ, and consisted of a Braconid (*Meteorus hyphantriæ* n. sp.); a Microgaster (*Apanteles hyphantriæ,* n. sp.); an Ophionid (*Limneria pallipes* Prov.), and a Tachinid, which, though probably new, we shall not attempt to describe. These last four have been mentioned in about the order of their relative abundance and consequent importance. An astonishing number of Web-worms were killed by the four parasites, and so many died from this cause and from the fungus disease previously mentioned as to fully warrant the prediction of almost complete immunity for the summer of 1887.

In addition to these parasites found last fall, the note-books of the Division show a prior breeding of another primary parasite, which will not be treated in detail here on account of insufficient material. It is an external feeder on the larva and belongs to the genus *Euplectrus.* It is closely related to *E. platyhypenæ,* described by Mr. Howard in Bulletin 5 of this Division.

Telenomus bifidus Riley.—A single egg of the moth of *H. cunea* is a very small affair, yet it is large enough to be a world for a little parasite, which undergoes all its transformations within it, and finds there all the food and lodgement required for the short period of its life.

In several instances batches of eggs of this moth were parasitized, and instead of producing young caterpillars they brought forth the tiny insects of this species. The batches of parasitized eggs were found July 27 upon the leaves of Sunflower, and August 18 upon leaves of Willow; judging from these dates it was the second brood of moths that had deposited them. There can be no doubt, however, that eggs

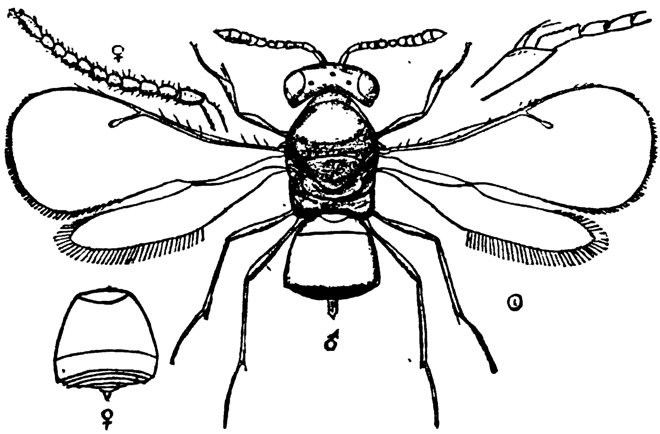

FIG. 23.—*Telenomus bifidus* (greatly enlarged).

produced by moths emerging from their cocoons in early spring had been parasitized as well. The female *Telenomus* was also observed, August 2, busily engaged in forcing its ovipositor into the eggs, and depositing therein. The female insect is so very intent upon its work that it is not easily disturbed, and one can pluck a leaf and apply a lens without scaring it away. The eggs soon hatch inside the large egg of the moth, and the larvæ produced soon consume the contents. This egg-parasite is a very useful friend, nipping the evil in the bud, so to speak.

Meteorus hyphantriæ Riley.—"This parasite (Fig. 24) has performed very good services during the caterpillar plague and has done much to check any further increase of the Web-worm. During the earlier part of the summer this insect was not very numerous, but sufficient proofs in the form of empty cocoons were observed to indicate at least one earlier brood. Towards the end of September, and as late as the 15th of October, very numerous cocoons of a second brood were formed; they could be found in all situations to which the caterpillar itself had access. But the great majority of them were suspended from the trunks and branches of trees, and chiefly from near the base of the trunk. Each cocoon represents the death of one nearly full-grown caterpillar, since the latter harbors but one larva of the parasite.* A careful watch was kept to see how such a suspended cocoon was formed,

* In only one instance the cocoon of this parasite was found inside that of its host.

but in vain. Once a larva had just started to make a cocoon, but it was prevented from finishing it by a secondary parasite, and it died. Another larva had already spun the rough outside cocoon, but became detached and dropped out of the lower orifice, and commenced a new one. The larva, suspended by the mandibles, evidently spins at first loose, irregular, horizontal loops around its body, until a loose cradle is formed. The silk secreted for this purpose hardens very rapidly when exposed to the air. When secure inside this cradle it lets go its hold with the mandibles, and finishes the soft inside cocoon in the usual manner. If the larva has dropped to the ground it still makes an outer loose cocoon, but the silken threads are thicker and much more irregular. In cocoons made during a high wind the threads that suspend them are much longer, reaching sometimes the length of 4 inches; the more normal length varies from 1½ to 2 inches.

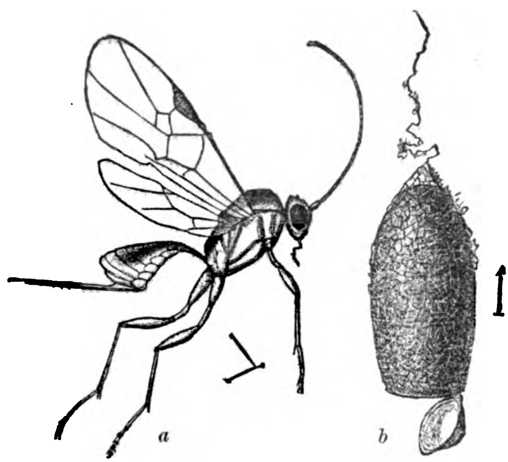

FIG. 24.—*Meteorus hyphantriæ*: *a*, female; *b*, cocoon (enlarged).

"To find out the length of time which this insect occupies in maturing inside the cocoon, 44 freshly-made cocoons were put in a glass jar. With a remarkable regularity but ten days were consumed by the insect in changing from the larval to the winged form. The winged *Meteorus* issues through a perfectly round hole at the lower end of the cocoon by gnawing off and detaching a snugly-fitting cap. There are several secondary parasites of the *Meteorus* which we may mention later, and they always leave the cocoon of their host by smaller holes cut through the sides. Most of the adults had issued by the first of November, but it is possible that some may remain in their cocoons until spring.

"In order to obtain the proportion between the *Meteorus* raised from cocoons and its parasites, *i. e.*, secondary parasites of *Hyphantria*, 450 cocoons were confined in a glass jar the latter part of September. Up to the first week in November only 70 specimens of *Meteorus* were bred from these cocoons, the rest giving out secondary parasites, which continued to issue up to date of writing (December 20, 1886). Thus, only 16 per cent. of the cocoons produced the primary, while 84 per cent. produced secondary parasites."

Apanteles hyphantriæ Riley (Fig. 25 represents a closely allied species).—"This insect was about as numerous as the *Perilitus communis*,

and did equally good service in preventing a further increase of the caterpillars. It appeared somewhat earlier in the season, and killed only half-grown caterpillars. From the numerous old and empty cocoons in early summer it was plainly seen that a first brood had been quite numerous, and that from these cocoons mainly *Apanteles* had been bred, and not, as during the autumn, mostly secondary parasites. The white silky cocoon is formed almost under the middle of a half-grown caterpillar, and is fastened securely to the object its host happened to rest upon, and but slightly to the host itself, which is readily carried to the ground by wind and rain, and can therefore only be found in position in the more sheltered places, such as cracks and fissures of the bark of trees. But one *Apanteles* is found in a caterpillar, so that each

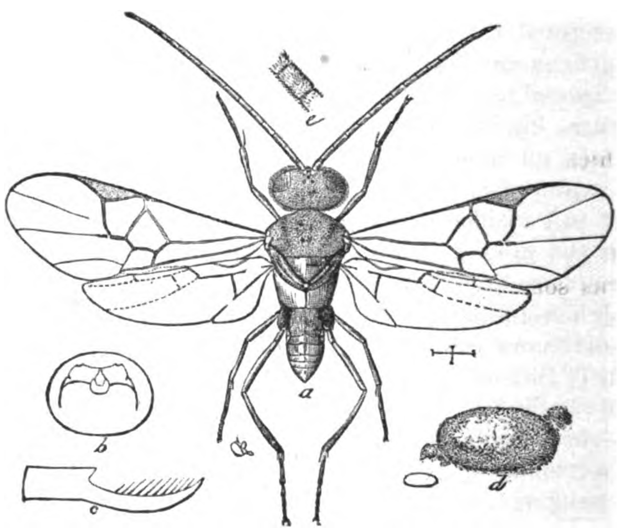

FIG. 25.—An *Apanteles*: *a*, female fly; *b*, outline of head of larva in position to show the chitinized parts of the mouth, the mandibles not visible, being withdrawn; *c*, one of its mandibles as seen within the head of a mounted specimen; *d*, cocoon; *e*, joint of antenna—all enlarged; natural size of *a* and *d* in hair-line.

white cocoon indicates, like a tombstone, the death of a victim. In some places, and notably upon the trunks of poplars, these cocoons were so numerous as to attract attention; it seemed as if the trunk had been sprinkled with whitewash. But notwithstanding such vast numbers, but two specimens of the architects of these neat cocoons were raised; all the rest had been parasitized by secondary parasites. It is barely possible, however, that some specimens may hibernate in their cocoons, since numbers of them have as yet (December 20, 1886) not revealed any insects. The winged *Apanteles* leaves the cocoon by a perfectly round orifice in the front, by cutting off a little lid, which falls to the ground. Its parasites, however, leave by small holes cut through the sides. These secondary parasites were very common late in September and

early in October, and busily engaged in inserting their ovipositors through the tough cocoon into their victim within. It seems as if the cocoons formed early in the season were on an average a little smaller than those formed later.

"The cocoons of this *Apanteles* are of a uniform white color, but exceptionally a distinctly yellowish cocoon is found. From these yellow cocoons nothing has so far been bred; but since, as we have elsewhere shown,* the color of the cocoon may vary in the same species, it is probable that the variation here referred to is not specific.

"Not quite one-half of 1 per cent. produced parasites of various kinds.

"*Limneria pallipes* Provancher.—In addition to the two Hymenopterous parasites treated of, a third one has been very numerous, and has done much good in reducing the numbers of caterpillars. This, an Ichneumonid and a much larger insect, does not form an exposed cocoon like that of the other parasites described. Yet a little attention will soon reveal large numbers of them. Upon the trunks of various trees, but chiefly upon those of the poplars and sugar maples, small colonies of caterpillars, varying in numbers from four to twelve, could be observed, which did not show any sign of life. When removed from the tree they appeared contracted, all of the same size, and pale or almost white. A closer inspection would reveal the fact that the posterior portion of the caterpillar had shrunken away to almost nothing, whilst the rest was somewhat inflated and covered with an unchanged but bleached skin, retaining all the hairs in their normal position. Opening one of these inflated skins, a long, cylindrical, brown cocoon would be exposed; this is the cocoon of the *Limneria* under consideration. As numbers of such inflated skins would always occur together, it was clearly seen that the same parent *Limneria* had oviposited in all of them. Most of the cocoons were found in depressions of the rough bark or other protected places. Single ones were but rarely met with. The Hyphantria larva in dying had very securely fastened all its legs into the crevices of the bark, so that neither wind or rain could easily dislodge them. Only half-grown caterpillars had thus been killed. Many of these inflated skins showed in the early part of October a large hole of exit in their posterior and dorsal ends, from which the ichneumons had escaped. Trying to obtain winged specimens of this parasite one hundred and forty of these cocoons—and only such as were not perforated in any way—were collected and put in a glass jar. Only a single female was produced from all up to time of writing, whilst very large numbers of secondary parasites issued from October 11 till the 20th of November, and doubtless others will appear during the spring of 1887, because some of these inflated skins show as yet no holes of exit.

"*Tachina* sp. (Fig. 26).—The parasites of *H. cunea* described so far all belong to the order Hymenoptera, which furnishes the greatest num-

* Notes on North American Microgasters, p. 7 (author's edition).

ber of them. But the fly now to be described is fully as useful as any of the others.

"Tachina-flies are very easily overlooked, because they resemble large house-flies, both in appearance and in flight, and their presence out of doors is not usually noticed on that account. Yet they play a very important rôle, living as they do in their larval state entirely in insects. During the caterpillar plague such flies were often seen to dart repeatedly at an intended victim, buzz about it, and quickly disappear. If the caterpillar thus attacked was investigated, from one to four yellowish-white, ovoid, polished, and tough eggs would be found, usually fastened upon its neck, or some spot where they could not readily be reached. These eggs are glued so tightly to the skin of the caterpillar that they can not easily be removed. Sometimes as many as seven eggs could be counted upon a single caterpillar, showing a faulty instinct of the fly or flies, because the victim is not large enough to furnish food for so many voracious maggots. If the victim happens to be near a molt, it casts its skin with the eggs and escapes a slow but sure death. But usually the eggs hatch so soon that the small maggots have time to enter the body of the caterpillar, where they soon reach their full growth, after which they force their way through the skin and drop to the ground, into which they enter to shrink into a brown, tun-like object (known technically as the coarctate pupa), which contains the true pupa. The caterpillar, tormented by enemies feeding within it, stops feeding and wanders about for a long time until it dies. As a rule not more than two maggots of this fly mature in their host, and generally but one. The caterpillar attacked by a Tachina-fly is always either fully grown or nearly so.

"Tachina-flies abounded during the whole term of the prevalence of the caterpillars. But it is impossible to state positively whether they were all bred from them or not, since the many species of this genus of flies resemble each other so closely that a very scrutinizing investigation would have been necessary to settle such a question. But there is no doubt that they were very numerous during the summer. Some maggots obtained from caterpillars kept for this purpose in breeding jars changed to the fly in six days; others appeared in twenty-three days, and still others, obtained at about the same time, are still under ground, where they will hibernate. The maggots of these flies do not, however, always enter the ground, as some were found inside cocoons made by caterpillars among rubbish above ground."

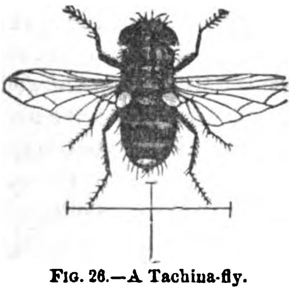

FIG. 26.—A Tachina-fly.

We have found, moreover, that three of these primary parasites of the Web-worm, viz, the *Apanteles*, the *Limneria*, and the *Meteorus*, were killed off at a serious rate late in the season by secondary parasites,

most of which belong to the family *Chalcididæ*, with the exception of three species of the Ichneumonid genus *Hemiteles*. So extensive has been this killing off of the primary parasites by the secondary, that were not the fates of the three classes, viz, the plant-feeder, the primary and the secondary parasites so interwoven, the destruction of these beneficial insects might be considered a serious matter in dealing with the plant-feeder.

We have not taken time to determine these secondary parasites specifically, but give a little table showing the number of species concerned, mentioning them only by their genera:

SECONDARY PARASITES.

On *Apanteles:*

1. *Hemiteles* sp.
2. *Elasmus* sp.
3. *Eupelmus* sp.
4. *Panstenon* sp.
5. *Cirrospilus* sp.
6. *Pteromalus* sp.
7. *Pteromalus* sp.

On *Meteorus hyphantriæ*.

1. *Hemiteles* sp. (= 1 on *Apanteles*).
2. *Spilochalcis* sp.
3. *Hemiteles utilis* Nort.
4. *Eupelmus* sp. (= 3 on *Apanteles*)
5. *Hemiteles* sp.
6. *Pteromalus* sp. (= 6 on *Apanteles*).
7. *Pteromalus* sp. (= 7 on *Apanteles*).

On *Limneria pallipes* Prov.:

1. *Eupelmus* sp. (= 3 on *Apanteles*).
2. *Tetrastichus* sp.
3. *Pteromalus* sp. (= 6 on *Apanteles*).
4. *Pteromalus* sp. (= 7 on *Apanteles*).
5. *Elasmus* sp. (= 2 on *Apanteles*).

The observations just recorded were made in the main during the summer of 1886, a season of exceptional abundance of the worms. We may add that, in accordance with our predictions in the first edition of this Bulletin, there was an immense decrease in the number of the worms with the opening of the spring of 1887. So many had been taken off by the fungus disease and by parasites that the result was that except in a few streets the worms did not become abundant. Moreover, the parking commission sent out carts and men as soon as the webs had begun to be easily seen, and so thoroughly were the nests destroyed that the second generation of worms attracted no attention whatsoever.

Moreover, whole rows of old Silver-leaved Poplars (*Populus alba*), more than 1,500 in all, were cut down during the winter of 1887–'88, and their places filled by young Red Oaks, Sugar Maples, and Silver Maples. Many of the Box Elders were also taken down, although these were in the main young trees. A number of old tree boxes were removed, and where the tree was large enough to stand up by itself and simply needed protection from horses, a coarse wire screen was substituted for the box with good effect.

SUMMARY OF THE HABITS OF THE FOUR SPECIES.

It follows from the above that we have to deal with four very different insects, each of them requiring modification in treatment, especially so far as winter work is concerned. Here, as in every other case in dealing with injurious insects, correct knowledge of the habits of the species to be dealt with must necessarily precede intelligent action, else we shall be apt to err, as did the authorities of our neighboring city, Baltimore, many years ago, by incurring a great deal of unnecessary expense without producing any beneficial result. Their blunder is historical. Observing that the elm trees around Cambridge, Mass., suffered from defoliation and were effectually protected by troughs of oil around the trunk, they ordered similar troughs of oil to be placed around their trees in Baltimore, which were also being defoliated. In Cambridge, however, the insect involved was the Spring Canker Worm (*Paleacrita vernata*), which has a wingless female that issues from the ground early in spring, and is effectually prevented by the oil troughs from ascending the trees; whereas the trees in Baltimore were suffering from the Galeruca, which we have just described, and which has ample wings in both sexes.

1. The imported Elm Leaf-beetle is a small yellowish beetle, about a quarter of an inch long, and marked with two longitudinal dark stripes on the back. It passes the winter in the beetle state in holes and crevices in the bark of trees, in fences and tree-boxes, in barns and out-houses, etc., and the eggs are laid on the young leaves of elms in April and May. The eggs are yellowish, elongate, and pointed, and are laid on end upon the leaves in groups of from five to twenty or more. The resulting worm feeds on the leaves, gradually skeletonizing and gnawing holes through them. The larvæ molt four times and transform to pupæ at the surface of the ground under grass and stones. There are several broods, and and the worms are pretty constantly at work through the months of June, July, and August.

This is an imported insect, is confined to the Elm (genus *Ulmus*), has a predilection for the European Elm and for trees in cities, and the female flies long distances.

2. The Bag-worm is one of our commonest native American insects, and its bags hang from the smaller limbs of our shade trees so as to be easily seen, especially in winter, when the leaves have fallen. These bags are made by the larva or worm which lives within them. The female moth is wingless, and only leaves the bag in which she passed her larval and pupal life after she has deposited her eggs in her empty

chrysalis skin or puparium. She then falls to the ground and perishes. The eggs remain in the bag all winter and hatch in spring into young worms, which scatter and at once make new bags, which increase with their growth and protect them from the attacks of birds.

The male moth is a small, black, hairy-bodied creature, with ample transparent wings, and escapes from the chrysalis after it is partially worked out of the hind end of the bag. This worm is a very general feeder, but is, on the whole, more injurious to evergreens than to deciduous trees.

This species has several insect parasites.

3. The White-marked Tussock moth has a very beautiful hairy larva or caterpillar marked with black and yellow and red. The female cocoons are to be found during the winter on the trees and upon neighboring fences and tree-boxes, and each cocoon is plastered with a number of eggs, protected by a white, frothy, glutinous covering. The eggs hatch in spring and the young worms feed upon the fresh leaves. The males spin their cocoons after three molts and the females after four. The moths issue in July, pair and lay eggs for a second brood of worms, which in turn transform and bring forth moths in October, the eggs from which hibernate. The male moth is active, with ample wings, which are brown, with a conspicuous white spot, while the female is pale and wingless, and only crawls out of her cocoon to lay her eggs thereon and die. This species is never found on evergreens, and is chiefly injurious to elms and maples, and prefers large and old trees to young ones, because of the greater shelter which they offer for its cocoons. In Washington it is yet chiefly confined to our parks, and it has not begun to be as injurious as in cities like Philadelphia and Baltimore, where the trees are older and larger. Two probable egg-parasites and seven parasites of larva and pupa are known to me.

4. The Fall Web-worm passes the winter in the pupa state. The cocoons are found during the winter principally at the surface of the ground, mixed with dirt and rubbish, or in cracks and crevices of tree-boxes, in fences, and under door-steps and basement walls. The first moths issue from these cocoons in May, and lay their eggs in flat batches on the under side of the leaves. The young worms feed preferably in company, webbing first one and then several leaves together, and gradually extending their sphere of action until a large part of the tree becomes involved. The worms become full grown in July and spin cocoons, from which a second generation of moths issue early in August and lay eggs, from which the worms hatch; so they are once more in force by the latter part of August. This is the species which did the damage last year. The parent moth is white, with a varying number of spots; is winged in both sexes; and the female prefers to oviposit on Box Elder (*Negundo aceroides*), the Poplars, Cottonwoods, Ashes, and Willows. The worm feeds, however, on many other trees, but not upon Conifers. It has numerous enemies and parasites.

REMEDIES AND PREVENTIVE MEASURES.

WINTER WORK.

The preventive measures that can be taken during winter time vary according to the species to be dealt with. For No. 1, or the Galeruca, which is confined to the Elms, no treatment of the trees themselves or of the boxes; in fact, no treatment that can well be given in the winter season will avail much in destroying the insect in its hibernating retreats, because the parent beetle finds shelter in all sorts of out-of-the-way places. It flies long distances, especially upon awakening from its winter torpor, so that it may be attracted to the trees from regions into which it is practically impossible to effectually pursue and detect it.

With No. 2, the Thyridopteryx, on the contrary, effective work can be done during the winter time or when the trees are bare. The bags which contain the hibernating eggs, and which are very easily detected, then may be gathered or pruned and burned. This work may be so easily done that there is no excuse for the increase of this species. Where intelligent action is possible the bags were better collected and heaped together in some open inclosure away from trees, rather than burned. By this means most of the parasites will in time escape, while the young Bag-worms, which will in time hatch and which have feeble traveling power, must needs perish from inability to reach proper food.

Much can also be done with No. 3, the Orgyia, because it also hibernates in the egg state upon the female cocoons upon the trunks and in all sorts of recesses.

In regard to No. 4, the Hyphantria, which is the species we are more particularly dealing with, something also may be done in the winter time by systematic clearing away of the cocoons from the sheltered places in which they may be found. These hibernating retreats are, however, so numerous about our houses and our grounds, that complete destruction of all cocoons becomes an impossibility.

ONE SIMPLE PREVENTIVE REMEDY FOR ALL.

It so happens, fortunately, that there is one thoroughly simple, cheap and efficacious remedy applicable to all four of these tree depredators. From the natural history facts already given it is clear that they all begin their work very much at the same season or as soon as the leaves are fairly developed, and arsenical mixtures properly sprayed on the trees about the middle of May and repeated once or twice at intervals

of a fortnight later in the season, will prove an effectual protection to trees of all kinds. This can be done at small expense, and will prove the salvation of the trees. An apparatus can be readily constructed, such as has been used on the grounds of the Department of Agriculture, on a sufficiently large scale to economize time and labor. It should consist of a water tank mounted on a cart and furnished with a strong force pump operated by one man and furnished with two sets of rubber tubing of a sufficient length (a hose reel can be constructed on top of the cart), each hose supported by a bamboo extension pole with a cyclone nozzle at tip. With such an apparatus as this three men could drive along the streets and thoroughly spray two trees simultaneously; while if it were found advisable, four independent tubes and four men to work them could be employed with a sufficiently powerful pump, and thus expedite the work. The details of the more important devices connected with this tank-cart are given in considering the Galeruca. The bamboo "extension pole" is used simply to stiffen the rubber hose and to enable the operator to elevate the spraying nozzle into the center of the tree and spray to a so much greater height. The same result can be accomplished by means of a brass rod, in sections, and this has the advantage of superior strength, and will consequently carry a heavier nozzle or a bunch of nozzles at the end.

The "Cyclone" or "Eddy-chamber" nozzle (see Fig. 6) is better suited for work of this kind on small trees than any yet in use. It is small, simple, cheap, will not clog, and gives an admirable spray. A combination nozzle may be made of several of these which will be readily supported by the section rod and will throw a more profuse spray.

The arsenical compound known as London purple is, as already shown, perhaps preferable to white arsenic or Paris green in that it is not so liable to burn the leaves while its color enables one to readily distinguish poisoned from non-poisoned trees. Moreover it is very cheap. From one-quarter to three-quarters of a pound of this substance should be used to a barrel of water, and with this quantity of water it is best to mix three quarts of cheap or damaged flour which will serve both to render the mixture adhesive to the leaves and also to lessen the tendency of the poison to burn the leaves. Three-quarters of a pound to the barrel may prove too strong a mixture for delicate and susceptible young trees, and it will be best for general application to make the amount from three-eighths to one-half pound to the barrel. Paris green will require a somewhat heavier dose—say from one-half to 1 pound per barrel of water.

A number of other means have been tried and are more or less effectual in destroying these defoliators. Such are the application of various other insecticides, particularly an emulsion of milk and kerosene, the burning of the webs (in case of the web-worm) by thrusting a lighted torch, made of various patterns, into the webs; but after full trial, nothing has been found more satisfactory than the arsenical mixtures

here recommended. They have the advantage over all other means that they kill directly the worms begin feeding, and at the same time have a preventive influence. Properly sprayed on the under side of the leaves so as to adhere, they are not easily washed off, and they not only kill, without injury to the tree, all the worms at the time upon such tree, but all those which may hatch upon such tree for a number of days and even weeks subsequently.

We are satisfied that with two or three special tanks, such as we have built at the Department of Agriculture, and a gang of three men to each, the trees of the city could be easily protected at a nominal cost beyond labor, and that two sprayings, one about the middle of May and one the first week in June, will effectually prevent the repetition of any such nuisance as that we suffered from last summer. Each gang of three men could properly protect in the neighborhood of from three hundred to five hundred medium-sized trees per day, and in ordinary seasons and in dealing with the web-worm it would only be necessary to poison such trees as are preferred by the insect.

We may here with propriety describe, as supplementary to the general consideration of machinery on pp. 19–22, two recently-invented machines which could be used to advantage in this work.

The first is the invention of Mr. A. H. Nixon, of Dayton, Ohio, and will answer very well for the spraying of arsenical solutions. The cyclone nozzle, with all its advantages on small or medium-sized trees, is not so well adapted for spraying very high trees, and Mr. Nixon's nozzle and several others which might be mentioned have an advantage in that they throw a spray to a greater height or distance, in a more powerful and narrower stream, which nevertheless breaks up into a floating spray.

We have personally tested Mr. Nixon's nozzle and find it is a very satistactory one. Mr. W. B. Alwood, the agent of the Division at Columbus, Ohio, in a report upon it, writes:

"The necessity of a good apparatus for spraying tobacco in a packing-house led Mr. Nixon to experiment with many different kinds of apparatus, until almost by accident he discovered that a jet of water projected against a wire gauze of proper sized mesh held at a certain distance would produce a perfect spray. He was several years in working up a scheme to utilize this newly discovered fact, and then succeeded very imperfectly, but produced an apparatus which found quite common use in his and other tobacco warehouses in the Miami Valley.

"However, some three years ago he conceived the notion of perfecting his nozzle and bringing it into shape for practical utility on a force-pump. In this I think he has succeeded most admirably. Several styles of apparatus have been made by him for using his nozzle in practical work both in doors and out. Those designed for outdoor work have especial reference to the destruction of insects. How useful these may prove I would not venture an opinion, not having had a chance to use them in actual work, but of the fact that his nozzle will produce spray as fine or as coarse as can possibly be desired there is not the possibility of a doubt, and this, too, without any waste of liquid.

"The pump used on his machines is a single cylinder double action force-pump of extremely simple mechanism and of great power and durability.

"The nozzle (in which lies all the mechanism which he can really call his own invention) is very simple. It consists of a brass nipple three-quarters to 1 inch in length, pierced by a small hole varying in diameter according to the amount of spray desired. This nipple screws on to the discharge pipe and on its outer end is screwed a chamber three-quarters to 1 inch in diameter and 3 inches long. These dimensions have been determined by experiment. The nipple and chamber are made of brass. On the outer end of the chamber is soldered a wire gauze varying in size of mesh to suit size of orifice in nipple.

"The nipples tested by me were as follows:

No. 1. One sixty-fourth inch orifice projected spray 10 feet in straight line; discharged pint of liquid in 20 seconds; pressure could not be measured, but I think was 75 to 100 pounds in all the tests. Spray floated like mist.

No. 2. One thirty-second inch orifice projected spray little farther and little coarser; discharged 1 pint in 15 seconds.

No. 3. Five sixty-fourths inch orifice projected spray 18 feet; discharged 1 pint in 8 seconds; spray coarser than previous, but floated well in the air.

No. 4. One-eighth inch orifice projected spray 25 feet; discharged 1 pint in 5 seconds; still coarser, but fell in perfect mist, completely wetting soil.

"The apparatus tested by me was really yet in the experimental stage but gave very satisfactory results.

"The special features which commend this nozzle are that it is very simple, discharges spray farther in a straight line than any apparatus ever tested by me, and the capacity is practically unlimited.

"The complete machines which Mr. Nixon had made and were tested by me were as follows:

"No. 1. Sulky cart, drawn by horse, which also furnished motive power to pump by gearing from wheel. This machine as timed by me was capable of going over 21 acres of ground in eight consecutive hours, and completely spraying any low crop. Tank holds 70 gallons; pump arranged inside and so rigged with safety valve that pressure could be made to suit requirements of the nozzle used. This machine could also be used as a hand-pump by throwing out of gear and putting on a lever.

"No. 2. Is a hand machine on trucks with a small rest wheel in front. Tank holds 40 gallons and can be used for all ordinary purposes of spraying beds and lawns; also mounted in a wagon would be very serviceable for spraying orchards.

"No. 3. Is a small machine, 15-gallon tank, intended for use indoors."

The second machine is the invention of Mr. John Bowles, of Washington, D. C., and is used for the purpose of vaporizing naphtha of grade 77. Experiments made by Mr. Bowles and witnessed by Mr. Howard with this machine upon the Web-worm were successful in killing the worms, leaving the foliage uninjured. Fig. 27 shows the machine in section. Mr. Bowles' description is as follows:

"The mechanism employed for the purpose of applying the oil in the form of spray consists, essentially, of an oil-compresser, combined with an air-compresser, so that both may be actuated by the same effort, the leverage being adjusted so that the greater pressure may be applied to the oil-compresser, and the communicating together of the streams of oil and air at a nozzle for their discharge.

The form of machine shown meets these requirements. S is an oil-tank, that, for convenience, may be mounted on wheels. P is a bellows, attached to the tank, and actuated by the board *h*, by means of the handle, V, being pivoted to the top of the tank at U. An oil-pump is shown, within the chamber of the bellows, having a suction pipe, *s*, extending into the oil, and a discharge-pipe, *w*, connecting with the oil-pipe E, while the air discharged from the bellows passes through the air-pipe D,

the oil-pipe being within the air-pipe, and both pipes meeting at the point of discharge, at the nozzle. The plunger or piston of the oil-pump is actuated by a rod

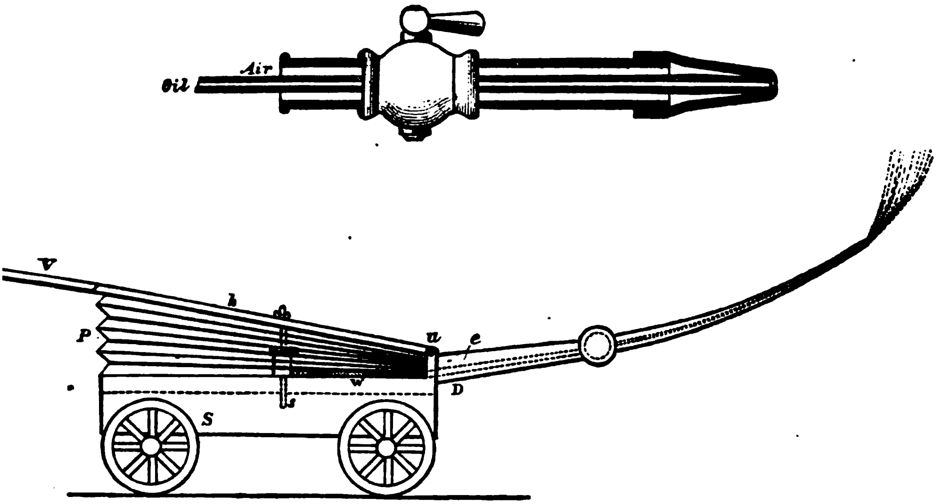

Fig. 27.—Atomizing machine invented by John Bowles, Washington, D. C.

pivoted to the board *h*, at a point that will give the oil-compresser such increased leverage as may be demanded for its proper discharge.

PRUNING AND BURNING.

The old and well-tried remedies of pruning or burning, or pruning and burning, will answer every purpose against the Web-worm in ordinary seasons, where it is thoroughly done and over a whole neighborhood. It must, however, be done upon the first appearance of the webs on the trees, and not, as was done by the Parking Commission of this city last season, after the first brood of worms had attained their full growth and many had already transformed to pupæ. The nests at that time had assumed large proportions, and their removal entire injured the appearance of many young trees. Then, too, they were piled upon an open wagon, which was dragged for many hours around the streets, permitting a large proportion of the worms to escape.

On the first appearance of the webs, which should be looked for with care, they should be cut off or burned off, and if cut off they should be burned at once. The "tree pruners," manufactured for the trade and well known to all gardeners, answer the purpose admirably.

The customary method of burning the nests is by means of rags saturated with kerosene or coal-tar and fastened to the tip of a long pole. An old sponge has been substituted to advantage for the rags, but probably the best substitute for this purpose is a piece of porous brick. In a pointed communication published in the *Evening Star*, of August 21, Major Key, agent of the Humane Society, thus describes the making of a brick torch: "Take a piece of soft brick, commonly

termed salmon brick, trim it to an egg shape; then take two soft wires, cross them over this brick, wrapping them together around the opposite side so as to firmly secure it; now tie this end to a long stick, such as the boys get at the planing mills, by wrapping around it; then soak the brick in coal-oil, light it with a match, and you are armed with the best and cheapest weapon known to science. Holding this brick torch under the nests of caterpillars will precipitate to the sidewalk all the worms on one or two trees at least from one soaking of the brick, and it can be repeated as often as necessary. Then use a broom to roll them under it and the work will be done, the controversy ended, and the tree saved."

Asbestos may also be used to advantage, and a little thorough work with some simple torch *at the right time* will in nearly every case obviate the necessity of the more expensive remedies later in the season, when the worms of the first brood have grown larger or when the second brood has appeared.

MULCHING.

After a bad caterpillar year, a little judicious raking together of leaves and rubbish around the trunks of trees which have been infested, at the time when the worms of the second brood are about full-grown and before they commence to wander, will result in the confinement of a large proportion of the pupæ to these limited spaces, where, with a little hot water or a match, they can readily be destroyed during the winter. Many of the caterpillars, of course, reach the ground by dropping purposely or falling accidentally from the branches, but the great majority descend by the trunk, and, finding the covenient shelter for pupation ready at the foot of the tree, go no farther. This has been tested on the Department grounds the past season, and is mentioned as a method of riddance supplementary only to others.

INFLUENCE OF TREE-BOXES.

However necessary it may be in cities to protect trees, by means of tree-boxes, against bodily injury, chiefly committed by mischievous boys and loafers, such protection should only be afforded for a limited time, or long enough for the growing tree to attain a sufficient thickness to prevent its being broken by any ordinary accident. After such a thickness has been reached the boxes ought to be discarded. They are unnatural, and both injurious to the tree and unpleasant to the eye. A great number of trees are forever injured by such boxes, and the great increase of some kinds of insects is solely due to them. For instance, the Maple Bark-borer (*Trochilium acerni*) is almost solely confined to the injured bark of maple trees protected by boxes, and is scarcely ever found in normally growing trees. Such tree-boxes furnish good shelters for the formation of cocoons, and afford winter quarters for many noxious insects. The Web-worm under consideration makes excellent use of them. A small Box Elder, with a trunk of about 4 inches in diame-

ter—a tree strong enough to thrive without protection—had been inclosed by the usual form of a wooden tree-box. This was removed, and the inside of the box and the collected rubbish in it was carefully investigated by one of our assistants, Mr. Otto Lugger. This is the result: 74 cocoons of *H. cunea;* 43 egg-masses of *Orgyia leucostigma;* 4 cocoons of *Acronycta americana*, and 1 pupa of *Anisota rubicunda*, besides innumerable old and empty pupal skins of these and other insects. It is to be added in this connection that this tree grew in a park in Baltimore, and was not as badly infested as trees in Washington.

A young tree in a tree-box ought to be firmly fastened at the top to all sides of the box, and this by means of flexible bands, to be renewed from time to time. In this manner a high wind would be prevented from producing any friction of the trunk or branches against the edges of the box. After the tree attains a size of 2 inches in diameter the tree-box ought to be removed, and the members of the city police should be instructed to pay especial attention to their further necessary protection. The shelter afforded by the wooden tree-boxes is, in my judgment, the prime reason why the Web-worm has become such a great nuisance in Washington. They should either be discarded entirely after the trees have attained a trunk diameter of 4 inches, and heavy penalties enacted for hitching horses or for in any way cutting or defacing the trunk; or, what would perhaps be safer, and certainly very much less objectionable, they should be replaced as soon as possible by round iron ones like those now in use on Fifteenth street, between New York avenue and K street. These will afford less shelter for cocoons, and are in every way less objectionable.*

WHITEWASHING OF TRUNKS.

Whitewash covers a multitude of sins; but sins should not be covered up, they should be eradicated, which a simple whitewashing will not do. A whitewashed tree is an eyesore, and whole rows of them, or even groves in parks treated in such a way, produce a sight to be deplored by all people admiring the beauty of nature. One is forcibly reminded of a grave-yard when walking through some of the Washington streets after sunset; the white trunks glisten like the broken shafts in an old cemetery. If the trunks of trees must be covered with lime at all, why not choose at least a color more in harmony with nature, the color of the bark for instance? There is no necessity, however, in Washington to whitewash the trunks of our shade trees. As a protection against flat and round-headed borers (species of *Chrysobothris* and *Saperda*) it is of value when a certain proportion of arsenic is mixed with it; but the principle "what is sauce for the goose is sauce for the gander" does not apply in this instance, and as a remedy for the Web-worm it is practically useless. . Only one of the insects mentioned can be in any way be lessened by this practice, and that is the species that Washingtonians are just now least concerned with, viz, the Orgyia.

* Since this was written a very simple and excellent mode of protection has been adopted by the Parking Commission of the District, viz., encircling the trunks with

It is very questionable whether the whitewash will destroy its eggs, but there is every reason to believe that the friction of the brush and the disengaging of many of the cocoons will cause the destruction of a certain number. On our larger trees the greater number of these cocoons are never reached by such whitewashing, because they are upon the higher limbs. The Web-worm cannot be affected by the practice, as the hibernating chrysalids and cocoons are not found upon the trunks. As against these negative results of whitewashing, however, we must put the injurious results that follow indirectly; because a great many of the enemies of the defoliators are destroyed by whitewashing. This is particularly the case with the egg-masses of spiders and many of the softer and more delicate cocoons of parasites.

BIRDS: THE ENGLISH SPARROW.

All four of these insects have a certain immunity from the attacks of birds: No. 1 by virtue of an offensive odor; No. 2 by the protection of its bag; Nos. 3 and 4 by the protection afforded by the hairs of the caterpillars, which are also mixed into their cocoons. A few native birds we have seen occasionally feed upon Nos. 3 and 4, but the English sparrow, to which, being emphatically a city bird, we should look for help, has never been known to attack any of them. In fact, we noticed and announced many years ago that in some of the northern cities (as Boston and Philadelphia) the increase of the Orgyia was indirectly a result of the increase of the English sparrow, which feeds in the breeding season upon smooth worms less harmful to our trees, and thus gives better opportunity for the rejected Orgyia to increase, a result still further promoted by the habit of driving away the native birds which the English sparrow is known to have. The same reasoning will hold true in respect of the Web-worm; and, putting all sentiment aside, we may safely aver that this bird is an impediment rather than an aid in preserving our trees from their worst insect defoliators. There is every reason to believe that the Bag-worm is carried, when young, from tree to tree upon the claws and legs of the bird, and its dissemination is thus aided and its destruction rendered more difficult; while the yellow suspended cocoons of the *Meteorus hyphantriæ* (the most important of the parasites of the Web-worm) are sought by the sparrow, probably being mistaken for grains of wheat.

While our feathered friends, owing to the sparrow's pugnacity, are now things of the past, and can only be seen in the spring when they pass through the cities in their migrations to more peaceable nesting places, yet something might be done to encourage their stay. Nesting places might be provided for them not alone by bird boxes, which, good in themselves, are at once occupied by the English sparrow; they must be afforded safer and natural quarters. This has been successfully achieved in portions of Europe and by the following very simple

methods: First, a number of low but dense trees and bushes, forming in themselves fine-looking groups, are surrounded by dense and thorny hedges, to prevent cats and other enemies of birds from entering the inclosed space. Second, in the crotches of taller trees, and chiefly in the first crotch, bundles of thorny branches are fastened in such a way as to prevent cats from climbing above them. Such bundles would not look well during the winter, but they could then be removed to be replaced by fresh ones in the early spring. A broad strip ot tin would, perhaps, answer the same purpose, but would not, at first, be as attractive to the birds themselves. A strict law against the use of slings, stones, and other weapons in the hands of the boys must, of course, be strictly enforced. In a very short time birds of various kinds will discover the safety of such places, and utilize them. Even if these birds should not alone avail against the ravages of insects, they would do good service, and their presence would pay for the little trouble of an invitation to them.

THE FUTURE OF OUR TREES—PRUNING.

Before closing this article it may be well to call attention to another danger from which our shade trees are threatened in the future. We refer to the reckless and almost cruel pruning which has in the past been indulged in, and which, if we are rightly informed by Mr. Saunders, the Parking Commission find it very difficult to prevent. No one looking to the future of our shade trees can have witnessed without indignation the gangs of careless men who periodically go through our streets cutting, hacking, and lopping indiscriminately and without intelligence the limbs of the trees until they have become on many of the older streets deformed and unsightly objects. The result of senseless pruning is easily seen on some of these older streets as compared with the trees in our parks which have been more often left alone and more intelligently pruned. Street shade trees should be pruned from below and not lopped off from the top, so that in the future there will result a tall straight trunk, not intercepting the view of the buildings from the street and yet furnishing the desired shade and beauty. The trees of such cities as Cambridge, New Haven, Saratoga, &c., may be cited by comparison with what ours are fast becoming. But there is another side to this question which justifies us in calling attention to it in this connection. To use the language of our Seventh Report on the Insects of Missouri, published in 1874, in treating of the Flat-headed Borer (*Chrysobothris femorata*), one of the most destructive borers of our trees: "Many a fine orchard tree, and many more city shade trees, receive their death shock from the reckless sawing off of limbs without effort being made to heal the wounds by coating with grafting wax, clay, or other protecting substances. Around such an unprotected sawed limb, as around the frustrum of a felled tree, the rain and other atmospheric in-

fluences soon begin their work of causing decay between the bark and the solid wood; and this is but the forerunner of greater injury by insects which are attracted to the spot, and which, though hidden meanwhile from view, soon carry the destruction from the injured to the non-injured parts."

There is, in fact, more danger that our trees in future (especially the Soft Maple) will begin to fall and perish from the ravages of Borers, as a result of reckless pruning, than that they will ever be seriously or permanently injured by leaf-eaters. These last, as we have seen, may be overcome, but the Borers are not only more deadly but more difficult to manage.

TREES WHICH ARE UNINJURED.

I have already indicated a few of the trees which are most subject to injury from this Web-worm. There is also quite a list of trees which are either very little affected or are never attacked, and in this connection it may be well to mention a few of these which are, not only on this account but in every other way, desirable for shade trees and should be strongly urged upon the Parking Commissioners as substitutes for those, like the Box Elders, which are so seriously affected. In this list of desirable trees which have immunity I would mention:

Tulip tree (*Liriodendron tulipifera* L.).
Sweet Gum (*Liquidambar styraciflua* L.).
Sweet Buckeye (*Æsculus flava*, Ait).
Ohio Buckeye (*Æsculus glabra*, Willd.).
The Maples (*Acer rubrum*, *A. saccharinum*, *A. pseudoplatanus*, and *A. dasycarpum*).
Honey Locust (*Gleditschia triacanthus* L.).
Kentucky Coffee Tree (*Gymnocladus canadensis*, Lamb).
Sour Gum (*Nyssa multiflora*, Wangerh.).
Beech (*Fagus ferruginea*, Ait).
Yews (*Taxus* spec.).

GOOD AND BAD EFFECTS OF OUR TREES.

The beauty of Washington is very greatly enhanced by its shade trees, and the Parking Commission deserve very great credit for the gigantic work they have carried out in the last fifteen years. But while these trees are and ought to be in the future an unending source of pleasure and healthfulness, yet here, as is so often the case, the good has some corresponding evil. This last, however, may be easily avoided. We hear much of malarial troubles in Washington, and the Potomac flats come in for nearly the entire blame. During the month of October our streets are constantly covered with fallen leaves from our shade trees, eddying and whirling about and carried by every heavy

rain into the sewer traps. Now, however vigilant the authorities may be during the heat of summer in cleaning out these traps, at the approach of cold weather the necessity for their frequent cleaning is supposed to be removed. As a consequence of this, vast masses of black, decomposing, and reeking leaves are left to fester during the late fall and early winter, and even through the whole winter, sending forth their injurious and insidious emanations from every street corner. From personal experience we are convinced that this is a source of much sickness hitherto almost entirely overlooked, and it behooves the authorities to have the traps on all the tree-planted streets thoroughly cleaned out immediately after the trees have become essentially bare.

PROSPECTS THE COMING SEASON.—CONCLUSION.

From the habits of the Orgyia as compared with the Web-worm there is good reason to believe that the former will become in the future more and more numerous and more and more of a nuisance, just as it has become the most grievous pest in Boston and Philadelphia and other cities where the trees are older. As to the prospects of a repetition of the Web-worm nuisance the coming season, the probabilities are that it will be very much less troublesome than it was in 1886. It is almost a universal rule in insect life that abnormal increase of a plant-feeding species is followed by a sudden check. This is due to two causes: *First*, the great multiplication of the parasites and natural enemies of the species which such undue increase permits; *secondly*, to the greater feebleness and tendency to disease resulting from insufficient food, which is a very general accompaniment of such undue increase. From the diseased condition in which the bulk of the last generation of the Web-worm was found, and from the great increase in its parasites that we know to have taken place from actual observation, we may safely expect exceptional immunity the present year.

SOURCE OF ILLUSTRATIONS.

Plate I is from a photograph. Figures 1, 2, 3, 4, 5, 6, and 11 are republished from former Government reports by the author. Figures 7, 12, 13, 14, 15, 20, 21, 22, and 26 are from the author's Reports on the Insects of Missouri. Figures 9, 10, and 25 are from other miscellaneous papers by the author. Figure 8 is from Hubbard, and figure 16 is from Glover; while figures 17, 18, 19, 23, 24, and 27 were drawn for this Bulletin and for our Annual Report as Entomologist to the Department of Agriculture for 1886.

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